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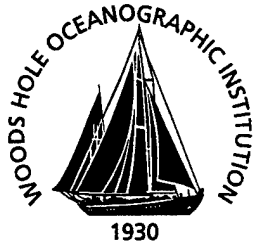
Woods Hole Oceanographic Institution



Ultimate Ocean Depth Packaging for a Digital Ring Laser Gyroscope

by

M. F. Bowen

July 30, 1998

Technical Report

Funding was provided by the National Science Foundation under Grant No. OCE-9710512

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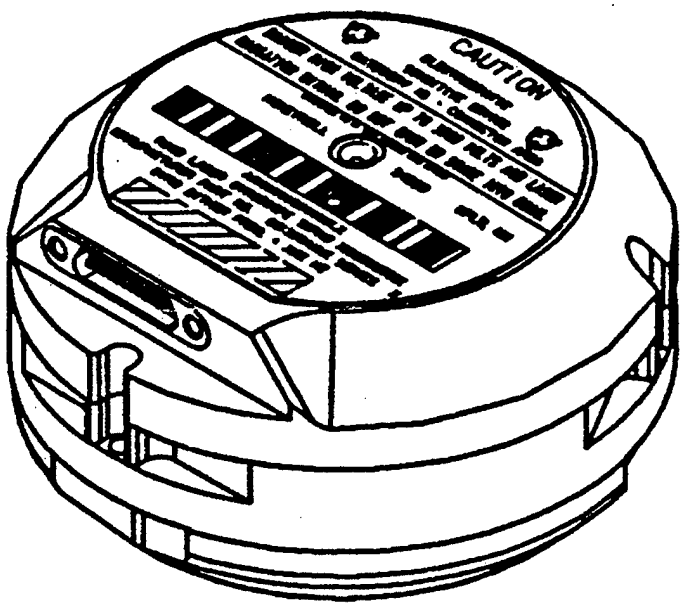

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Dr. Timothy Stanton

Department of Applied Ocean Physics and Engineering

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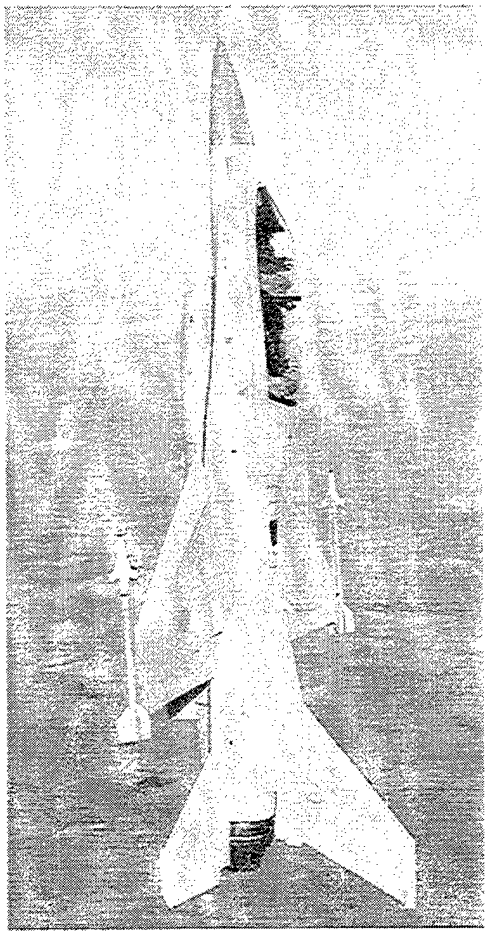
Prepared By:
M.F. Bowen

Version 1.0
30 July 1998



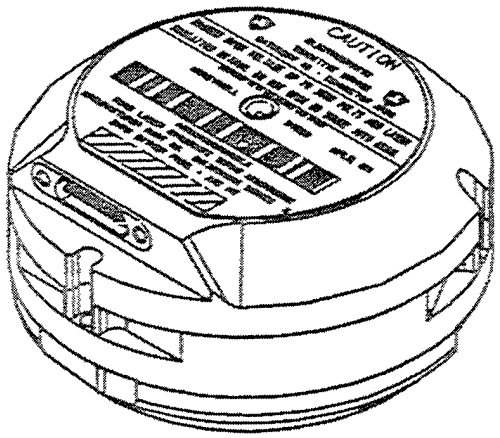
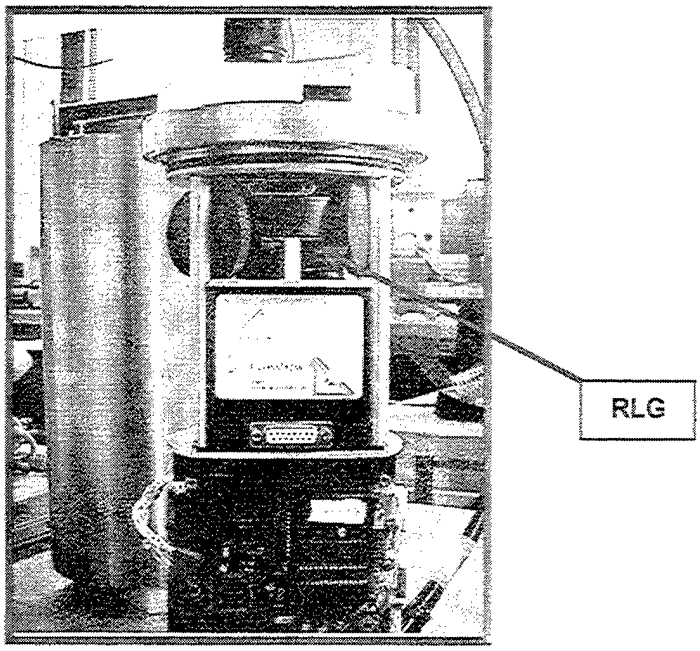


Figure [1] Fighting Falcon RLG Platform

Ultimate Ocean Depth Packaging for a Digital Ring Laser Gyroscope



Contents

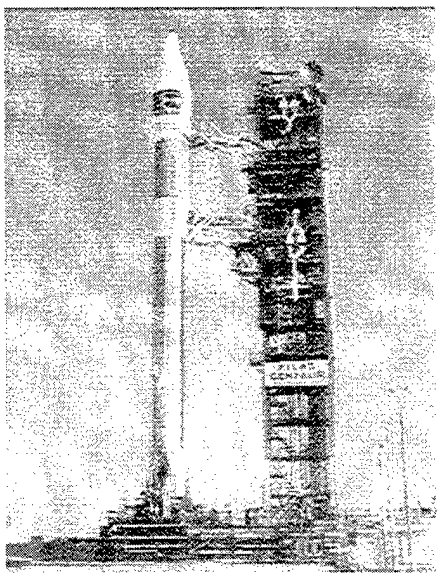
Abstract 3
1.0 Introduction 4
1.1 Package Design 4
1.2 Operational Advantages 4
2.0 RLG Deep Sea Platforms 5
2.1 Deep Submergence Vehicle (DSV) ALVIN 5
2.2 Remotely Operated Vehicle (ROV) JASON 5
2.3 Autonomous Underwater Vehicle (AUV) ABE 6
3.0 Instrument Housing 6
3.1 Seamless Housing Bell 6
3.2 Endcap and Accessories 7
3.2.1 Axial Registration Bracketry 7
3.2.2 Feedthrough Connectors 8
3.2.3 Operational Modes 8
3.3 Pressure Rating 8
4.0 Instrument Chassis 9
4.1 Components 9
4.1.1 Honeywell RLG and Anti-Vibration Mount 10
4.1.1.1 Power and Data 10
4.1.1.2 Connections 10
4.1.1.3 Mechanicals 10
4.1.1.4 Reliability 10
4.1.2 Crossbow DMU-VG 11
4.1.3 Axiom HC11 Single-Board Computer 11
4.1.4 WHOI UART PCBs 11
4.1.5 WHOI Power Supply Interface 11
4.1.6 WHOI Battery Backup 12
4.2 Chassis Wiring Diagram 13
4.3 Power Supply Interface Circuit Diagram 14
5.0 References 12
6.0 Mechanical Drawings 15-25

Figures

Figure [1] Fighting Falcon RLG Platform and RLG Outline Drawing 1
Figure [2] Launching the ALVIN DSV 5
Figure [3] Launching the JASON ROV 5
Figure [4] Launching the ABE AUV 6
Figure [5] Seamless Titanium Housing Bell 6
Figure [6] Endcap and Axial Registering Connector Guard 7
Figure [7] Bracketry Drawings RLG-98-011, RLG-98-012 7
Figure [8] Endcap Detail, Drawing RLG-98-017 8
Figure [9] Pressure Statistics 9
Figure [10] RLG above DMU in Anti-Vibration Mount 9
Figure [11] Crossbow 6-Axis DMU 10
Figure [12] Axiom Single-Board Computer Dimensions 11
Figure [13] 24 C-Cell Alkaline Battery Pack 12
Figure [14] Chassis Wiring Block Diagram 13
Figure [15] Power Supply Interface Circuit Diagram 14

Abstract

A Honeywell GG1320AN Digital Ring Laser Gyroscope (RLG), typically an aviation sensor, has been adapted for use as part of a navigation package rated to ocean depths of 6,000 meters. Researchers and engineers at the Deep Submergence Laboratory (DSL) of the Woods Hole Oceanographic Institution (WHOI) designed a high-density instrument package around the basic RLG. The integrated instrument is modular and field serviceable. It includes a chassis, housing, a Crossbow 6-axis dynamic measurement unit (DMU), battery backup, power regulation, support circuitry and robust interfaces. A pressure-proof titanium case and non-corroding accessories ensure that the RLG will remain unaffected by prolonged immersion in seawater. Associated mounting bracketry allow the housing to be axially registered alongside the navigation suites of various deep diving WHOI assets, or with any host platform capable of carrying a 25 pound payload. Primary RLG platforms will be the manned deep submergence vehicle ALVIN, the unmanned remotely operated vehicle JASON, and the unmanned autonomous vehicle ABE. As an extremely accurate yaw rate measuring device, the RLG will provide navigation data far more reliable and precise than has been available to scientists in the past. The WHOI RLG has been used successfully on one JASON cruise. (197) Keywords: submersible, navigation, gyroscope.



Atlas Centaur RLG Platform

1.0 Introduction

A Honeywell Model GG1320AN Digital Ring Laser Gyroscope (RLG) was obtained by the Deep Submergence Operations Group (DSOG) of the Woods Hole Oceanographic Institution (WHOI) through a grant from the National Science Foundation (NSF). The RLG arrived in-house as a stand-alone unit (Figure [1]) with a military specification, software guidelines and mounting documentation. In order to use this precision navigation sensor effectively with various deep submergence assets of the National Deep Submergence Facility, a project was undertaken to design and build an "ultimate-ocean-depth" (6,000m) instrumentation package, which would highlight the RLG as its primary sensor.

1.1 Package Design

The new RLG package had a number of assumed requirements. The design had to withstand prolonged operations at extreme ocean depths. It would experience equally stressful terrestrial environments, regularly transferred from one DSOG asset to another, shipped long distances, and handled by various operations groups around the world. A dense packing factor was desirable due to the limited payload capabilities of most unmanned underwater vehicles (ROVs and AUVs) such as JASON and ABE. The packaging challenge was undertaken by researchers and engineers at the Deep Submergence Laboratory and was completed in less than six weeks.

1.2 Operational Advantages

Engineers of the DSOG hope that the RLG will solve a long-standing problem with the measurement of heading on deep-diving vehicles of all kinds. True heading is essential for a variety of geophysical measurements as well as for ocean floor map-making. For example, when a sonar map is to be produced, true heading must be registered within the long-baseline navigation net, otherwise specific stations and samples will not be properly located.

Currently, a mechanical free gyro is used to measure vehicle heading (yaw rate) changes and a flux gate compass is used to measure absolute heading. (ROVs and AUVs cannot normally carry true north-seeking gyroscopes because of their large size.) The smaller free gyro has good dynamic properties and performs adequately in a vehicle's servo-loop (or auto-heading) software, but a flux gate compass is too heavily filtered for servo purposes.

To date vehicle navigators have been limited to the blending of heading information from these two sensors and they have been faced with two significant problems. First, the free gyro must be initialized to acquire a "true" heading reference and the flux gate compass must be relied upon to provide that reference. However, the compass can be corrupted by local magnetic anomalies, particularly those that are found in deep volcanic terrain where heading deflections of several tens of degrees are not uncommon. Second, the mechanical gyro can drift up to several degrees per hour so it must be regularly reset. The strong possibility of resetting the gyro to a corrupted compass reference can produce incorrect heading values for the remainder of a dive.

The RLG solves both of these problems. Because the RLG drift rate is extremely low (a fraction of a degree per day), it can be initialized in concert with a support ship's true north-seeking gyro prior to vehicle deployments. Since the unit is battery-backed and has very low drift, it maintains the north heading reference and does not have to be reset throughout a typical ROV or AUV dive, which may last several days. Use of an RLG brings vehicle heading information to new levels of reliability and accuracy.

2.0 RLG Deep Sea Platforms

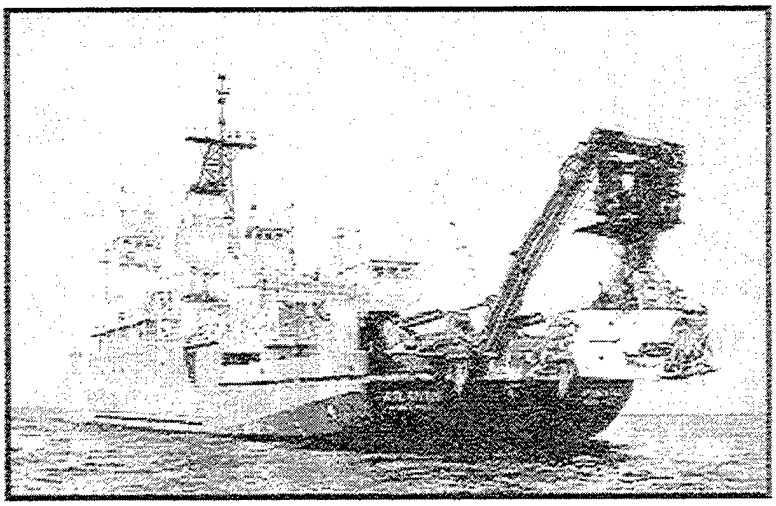


Figure [2]: Launching the ALVIN DSV

2.1 Deep Submergence Vehicle (DSV) ALVIN

The ALVIN will not use the pressure-proof housing provided with the package. Instead the RLG chassis and its integral titanium endcap will be mounted inside the one-atmosphere personnel sphere. A lightweight plastic housing tube and plastic endcap will replace the heavier, titanium housing bell. Auxiliary connections on the plastic endcap that do not ordinarily penetrate the housing will be made available to ALVIN operators.

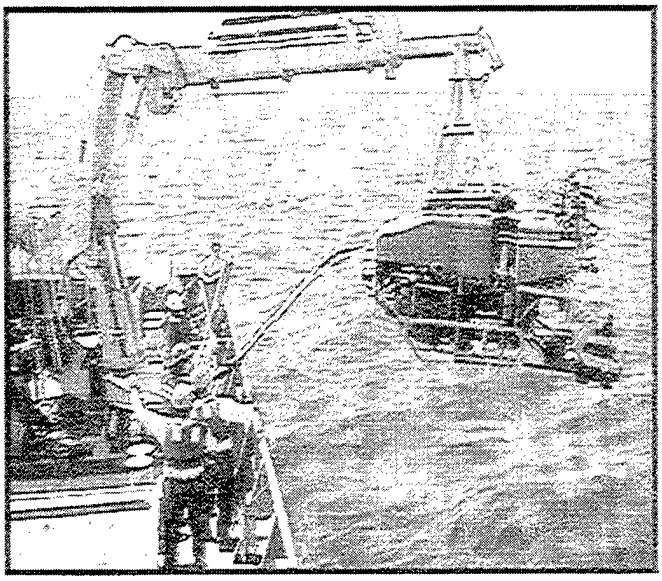


Figure [3]: Launching the JASON ROV

2.2 Remotely Operated Vehicle (ROV) JASON

The JASON vehicle (Figure [3]) has an existing 6-axis attitude package on board. In preliminary field operations the RLG will be registered to the planes of the JASON sensors so that complementary data may be examined. In this application the RLG in its housing will be mounted to the side of the main ROV body.

Figure [4]: Launching the ABE AUV

2.3 Autonomous Underwater Vehicle (AUV) ABE

The scheme for mounting the RLG onto the ABE vehicle (Figure [4]) has not yet been specified. The RLG and its housing will most probably reside on the lower of the three main pods (white).

3.0 Instrument Housing

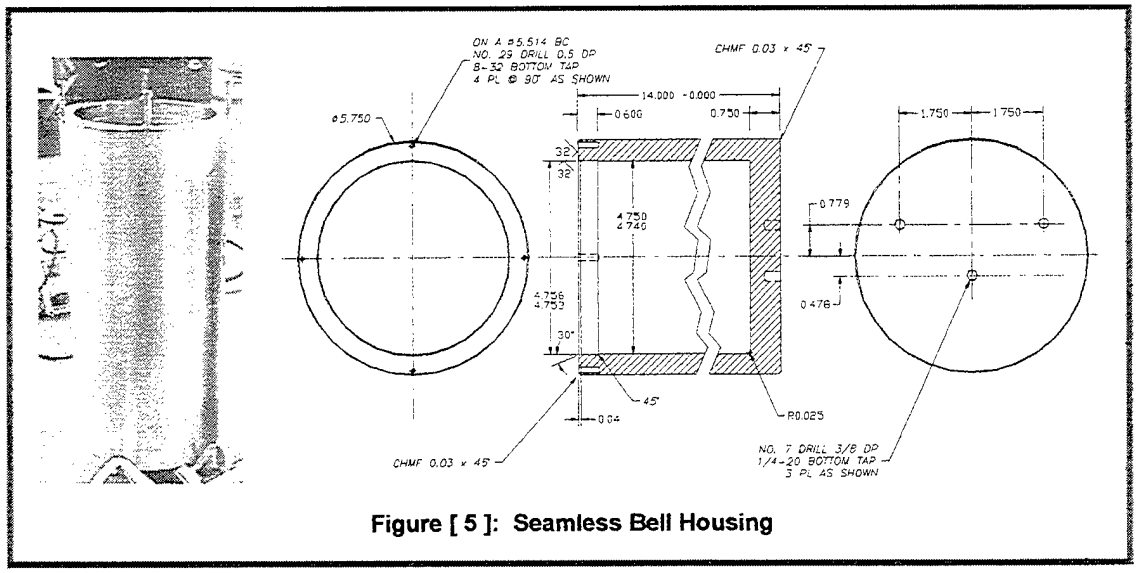


Figure [5]: Seamless Bell Housing

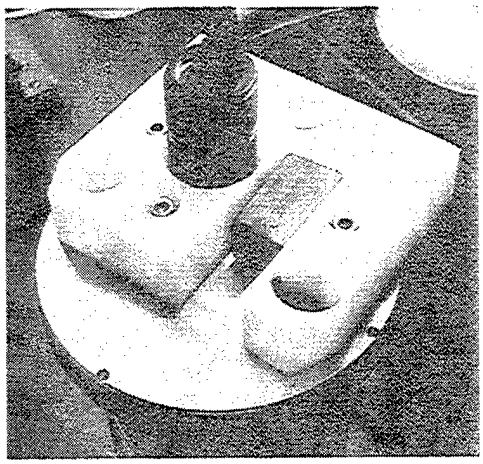
3.1 Bell

The RLG bell housing (Figure [5] and Drawing RLG-98-016) is unconventional for a grade 5 (6AL-4V alloy) titanium housing that is longer than most 8 inch lathe cutting bars and that has a outside diameter greater than 4 inches. In this case the housing had to be 5.75 inches OD, 14 inches long, with a 0.5-inch thick wall and a 0.75-inch thick flat endplate to meet or exceed the depth specification.

A conventional housing would consist of two endcaps and a tube; a process involving trepanning a solid rod to produce a tube and an internal slug. However, if the package in this project were to be especially reliable, the elimination of one endcap was deemed essential. A boring process performed by a specialty machine shop was arranged rather than employing the usual trepanning. Although the slug normally left over from the trepanning process is somewhat valuable in that it can be used to make another smaller

housing, it was decided that the loss of the slug into shavings from the boring process was a cost-effective tradeoff.

A tube with one welded endcap was also considered, but producing a seamless bell (as shown above) in a single $600 boring operation was logistically sound and efficiently eliminated additional #2 endcap design time, fixturing, machining and welding.



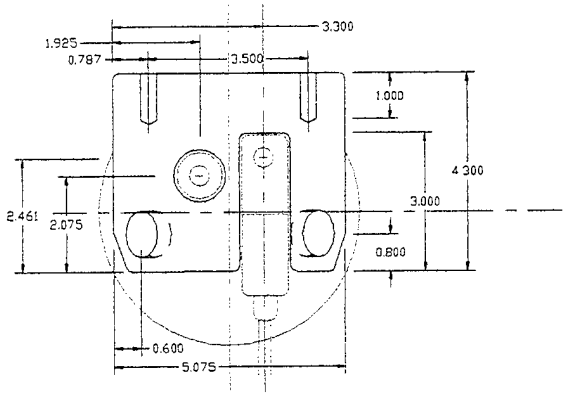


Figure [6]: Endcap and Axial Registering Connector Guard

3.2 Endcap and Accessories

The endcap (Figure [6] and Drawing RLG-98-017) was designed with both face and radial o-ring seals. The radial groove is beveled on the inner surface to capture and hold the seal. The endcap is secured to the bell by four 316 stainless screws. When the endcap is separated from the housing bell the entire chassis and battery pack are removed with it. This design allows the bell to be safely set-aside during trouble-shooting sessions.

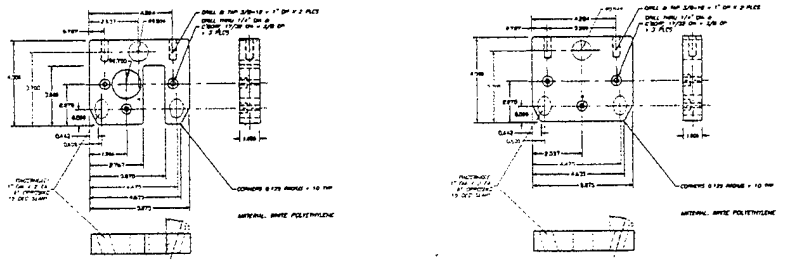


Figure [7]: Bracketry Drawings RLG-98-011, RLG-98-012

3.2.1 Axial Registration Bracketry

The RLG and the DMU are stacked and solidly affixed to the endcap longitudinal centerline. Both sensors are rotationally registered within half a degree of each other, and of the outboard threaded bolt patterns of both the housing bell and endcap.

The bolt patterns accept the axial registration bracketry (Figures [6] [7]), which is made of one-inch thick, white polyethylene. The bracketry transfers the planar alignment of the RLG and DMU to the host vehicle. The bracketry contains three finger holes to aid in separating the endcap from the bell. The endcap bracket surrounds the 7-pin bulkhead connector and protects it from rotational stresses.

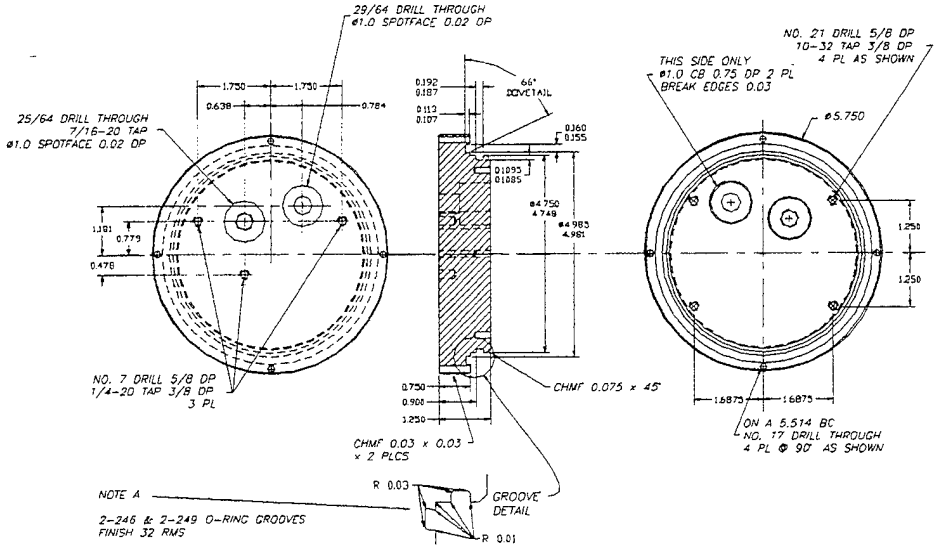


Figure [8]: Endcap Detail, Drawing RLG-98-017

3.2.2 Feedthrough Connectors

Two Impulse bulkhead feedthroughs were added to the endcap (Figure [8]): LPBH-7-FS\SS and BH-4-MP\SS. The 7-conductor, low-profile bulkhead provides external power from the platform and outputs serial information. The 4-conductor bulkhead accepted both a shorting plug and a standard dummy plug depending on the operational mode.

3.2.3 Operational Modes

When a standard dummy 4-pin plug is in place the unit is fully enabled (ON) using either external (vehicle) or internal (battery) power supplies. When a 4-pin shorting dummy is in place the power supplies would be interrupted. This mode is necessary to preserve battery power during long OFF periods such as during shipping or during long transit when the host vehicle may be powered down.

3.3 Pressure Rating

The assembled housing will fail at 19,055 psi or 12,929 meters or 42,417 feet (Figure [9]). It has been pressure tested to a working depth equivalent to 10,000 psi or 6,600 meters or 21,650 feet. The design allows for a 1.94X safety margin in pressure tolerance.

Figure [9]: PRESSURE STATISTICS

TITANIUM ALLOY 6AL-4V, GRADE 5
Yield Stress: 120.0000 Ksi
Poisson's ratio: 0.3250
Density: 0.1610 lb/cu in
Elastic Modulus: 17.0000 Mpsi

TUBE CONFIGURATION ALONE (External Pressure)
Inner Diameter: 4.7500 inches
Outer Diameter: 5.7500 inches
Wall Thickness: 0.5000 inches
Tube Length: 14.0000 inches
Weight in air: 18.59 lbs
Weight in water: 5.12 lbs
Failure mode: Thick wall crush
Collapse pressure: 19.0548 Ksi (42417.0ft underwater)
Thin wall collapse mode: 2 nodes
Thin Wall Collapse at: 43,604 psi (97,064 ft underwater)

ENDCAP CONFIGURATION ALONE (External Pressure)
Endcap Circular, Fixed
Free Diameter: 4.7500 inches
Outer Diameter: 5.7500 inches
Endcap Thickness: 0.7500 inches
Weight in air: 3.14 lbs
Weight in water: 2.41 lbs
Endcap Failure at: 24,084 psi (53,612 ft underwater)

TUBE PLUS ENDCAP CONFIGURATION
Tube Inner Diameter: 4.7500 inches
Tube Outer Diameter: 5.7500 inches
Tube Wall Thickness: 0.5000 inches
Tube Length: 14.0000 inches (Endcap Circular, Fixed)
Free Diameter: 4.7500 inches
Outer Diameter: 5.7500 inches
Endcap Thickness: 0.7500 inches
Combined Weight In Air: 24.86 lbs ;
In Water: 9.95 lbs
Initial failure caused by:
Tube Thick Wall Crush at: 19,055 psi (42,417 ft underwater)

4.0 Instrument Chassis

4.1 Components

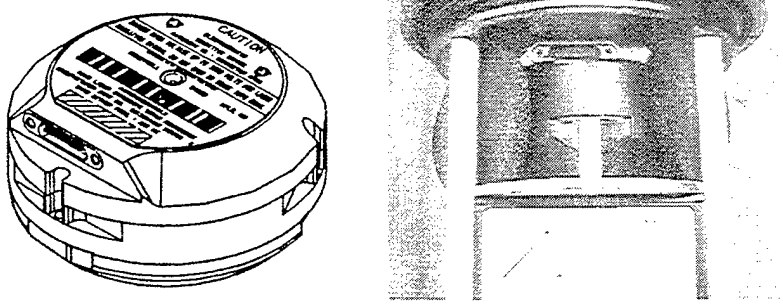


Figure [10]: RLG above DMU in Anti-Vibration Mount

4.1.1 Honeywell RLG and Anti-Vibration Mount

The Honeywell Dig-Gyro RLG (Figure [8]) provides rapid angular rate measurements in a multiplexed system. Compared to other rate sensors used by the DSOG the RLG has an extremely low drift rate over time. This capability is important for navigating unmanned deep-diving platforms that may be deployed for days at a time.

4.1.1.1 Power and Data

All data from the gyro is obtained in digital form. The unit requires +15 and +5V power inputs and is mechanically self-contained. The output provides tri-stated bi-directional asynchronous serial communications at 1 MegaBaud with an 8-N-1 data byte format.

4.1.1.2 Connections

The connection for the power and signal interface to the RLG is made through a 25 pin micro D pair. The RLG will mate with a MIL-C-83513/1 or a MIL-C-83513/3 connector, and the internal contacts are compatible with a 10147476-101 Honeywell bulkhead connector. Interconnect cable lengths are no longer than 3 feet per specifications.

4.1.1.3 Mechanicals

The RLG includes a laser block assembly based on an equilateral triangular 2.0 inch per leg path-length glass-ceramic block. On the block are mounted two path-length control transducers, a readout mirror and a mirror-mounted package, which supports readout electronics and photodiodes. The block cavity is filled with a mixture of helium and neon gases. The laser block assembly is mounted within a housing that consists of an aluminum base and cover.

In order to facilitate gyro dither, the laser block mechanical interface to the housing is accomplished by means of a Super Invar dither spring. Semi-rigid upper and lower chassis plate assemblies actively dampen the dither vibration that is translated to the outer case during RLG operation. Surrounding the unit with four circular open-cell foam cushions and ultra-stiff aluminum chassis rods provides additional dampening and audible noise reduction.

Also mounted within the aluminum housing is a set of electronic components, which provide the electrical interface to the gyro. The internal electronics provide the high voltage required for laser operation, control of gyro functions and readout of gyro information upon system request. This approach reduces system-level complexity and reduces requirements for electrical interface with the host WHOI system, which includes low voltage power inputs and a standard digital bus.

4.1.1.4 Reliability

The gyro case is environmentally sealed, is filled with dry nitrogen gas with a five- percent helium-4 tracer, and enclosed within a two-piece formed nickel-iron magnetic shield. The RLG can withstand impacts of 30 g's applied in any axis. It has a depth rating of 2,000 feet and an altitude rating of 70,000 feet. Its mean operating life is 100,000 hours with a mean time between failure (MTBF) of 150,000 hours or greater. The mature field random MTBF is 300,000 hours or greater. This military grade sensor should provide DSOG with years of significant service.

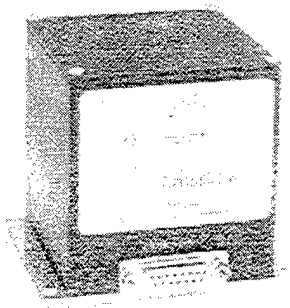


Figure [11]: Crossbow 6-Axis DMU

4.1.2 Crossbow DMU

The Crossbow DMU-VG (Figure [11]) is an intelligent six-axis measurement system designed for accurate X,Y,Z acceleration and angle measurements in dynamic environments. The DMU outputs inertial acceleration and angular rate measurements formatted for integration with the WHOI RLG system. The unit allows for data to be requested via serial command or to be transferred continuously. The DMU outputs stabilized pitch and roll calculations for platform stabilization. Measurements taken by the DMU are complementary to data from the RLG and other navigation systems on the host platform such as the bottom-lock Doppler. Other common DMU applications include GPS navigation, dynamic positioning, antennae pointing and flight data testing (Figure [1]).

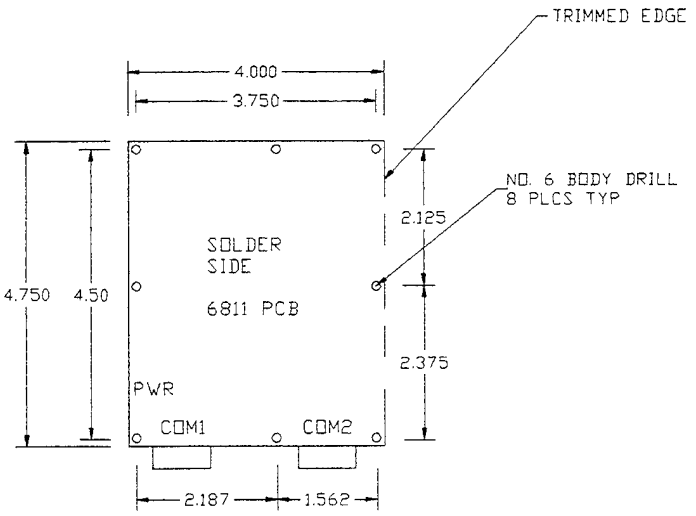


Figure [12]: Single-Board Computer Dimensions

4.1.3 Axiom HC11 Single-Board Computer

The Axiom HC11 single-board computer (Figure [12]) is a functional development system which requires a low voltage DC input and outputs to a standard serial cable. The HC11 will process the serial data from the two sensors and will compute heading and attitude information, which is then is passed on to the host vehicle over a serial interface. The Axiom is mounted in front of the RLG's backup battery pack and behind two UART and one power supply printed circuit boards. It is the largest circuit board in the package.

4.1.4 WHOI UART PCBs

Two universal asynchronous receiver-transmitter (UART) printed circuit boards are mounted in the RLG chassis. Each UART board contains a 16-byte FIFO buffer. The RLG UART provides an asynchronous serial interface between the RLG and the HC11. The Crossbow UART provides a similar interface to the Crossbow sensor. The RLG interface operates at 1 MegaBaud. The Crossbow interface operates at 38.4 KiloBaud. The serial interface to the host system is provided by the Axiom HC11.

4.1.5 WHOI Power Supply Interface

This circuit card provides an isolated 15 VDC along with an isolated 5 VDC to power the RLG. A separate isolated 15 VDC is also generated to power the Crossbow DMU-VG and the Axiom HC11 development board. The Datel switching converters employed by this circuit are exceptionally quiet and exceed the RLG's strict power supply noise specification. The power interface board has over-voltage and over-current protection on all inputs and outputs.

Detail of the WHOI circuit is shown in Figure [15]. Q1, Q2 and Q3 and their associated components provide 18 to 72 volts and the internal battery pack consisting of 24 alkaline c-cells. Q3 is the

main power switch and it is normally biased ON via Q2, which supplies a constant gate-to-source voltage of approximately 12.7 volts. When an external supply (host vehicle) is connected between pins 2 and 3 of J1, Q1 is biased ON which shunts the base drive of Q2, thus turning it OFF. With Q2 off, the gate of Q3 is held via the 220K resistor at the same voltage as its source, thus turning Q3 OFF. The IN4002 blocking diode is now forward biased and routes power directly to the input of the DC to DC converters. The transition is nearly instantaneous and the DC to DC converter input filter capacitors are more than adequate to hold the load while the power switches. Shorting pins 1 and 3 of J1 will also turn Q3 OFF. This provides a means of preserving the battery pack during long periods of shipping or storage.

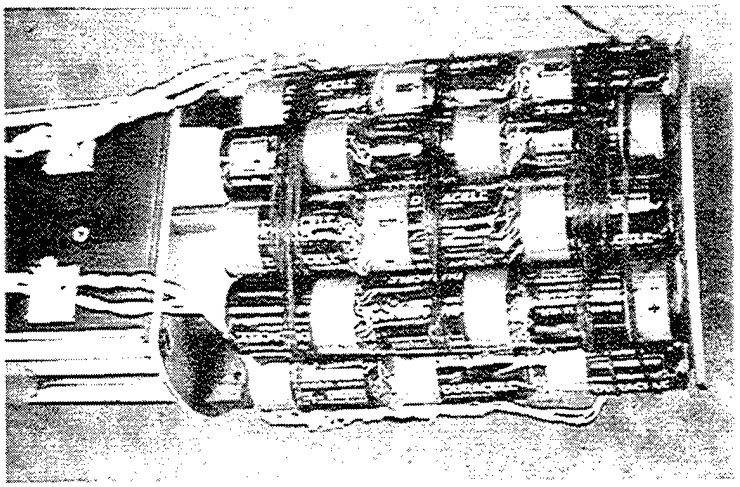


Figure [13]: 24 C-Cell Alkaline Pack

4.1.6 WHOI Battery Backup

The 24-cell alkaline battery pack (Figure [13]) occupies the lower aft quarter of the housing volume. The pack wraps around four printed circuit boards. Three isolating Phenolic rods penetrate the pack to provide stiffness and alignment. The batteries are wired in parallel and produce a nominal 40-volt supply, which is employed when the RLG is not powered by the host vehicle during short maintenance periods or between deployments. When the host vehicle applies external power to the RLG system, the power and regulation PCB automatically disables the internal battery pack. Using a shorting plug, the operator can disable the pack manually for long periods such as during shipping and storage. Whenever power is interrupted to the RLG, critical calibration data is also lost, which is why the backup pack is important to the system. Pack life is estimated at about 22 hours. It can be replaced with a spare pack in less than one hour.

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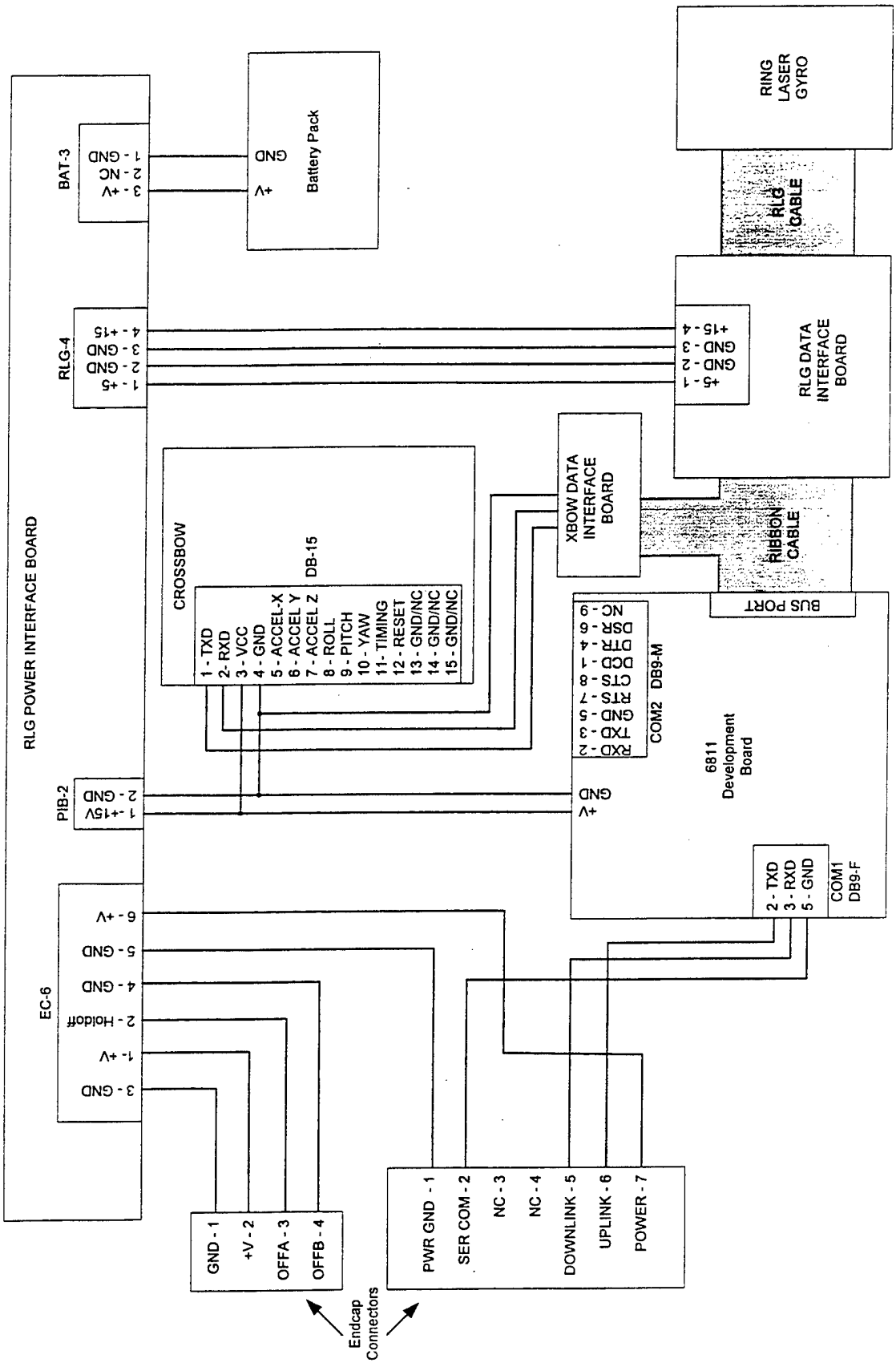
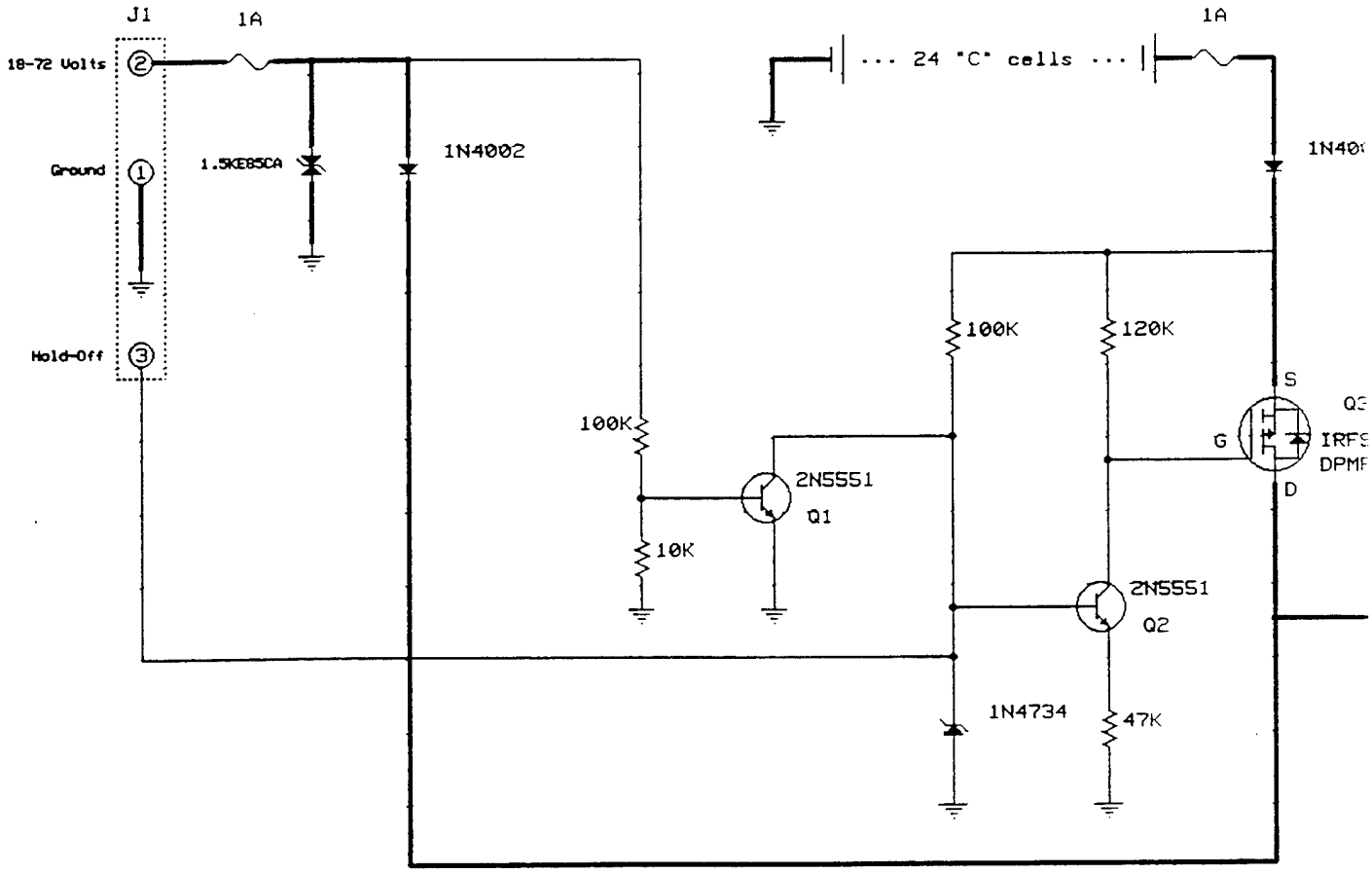
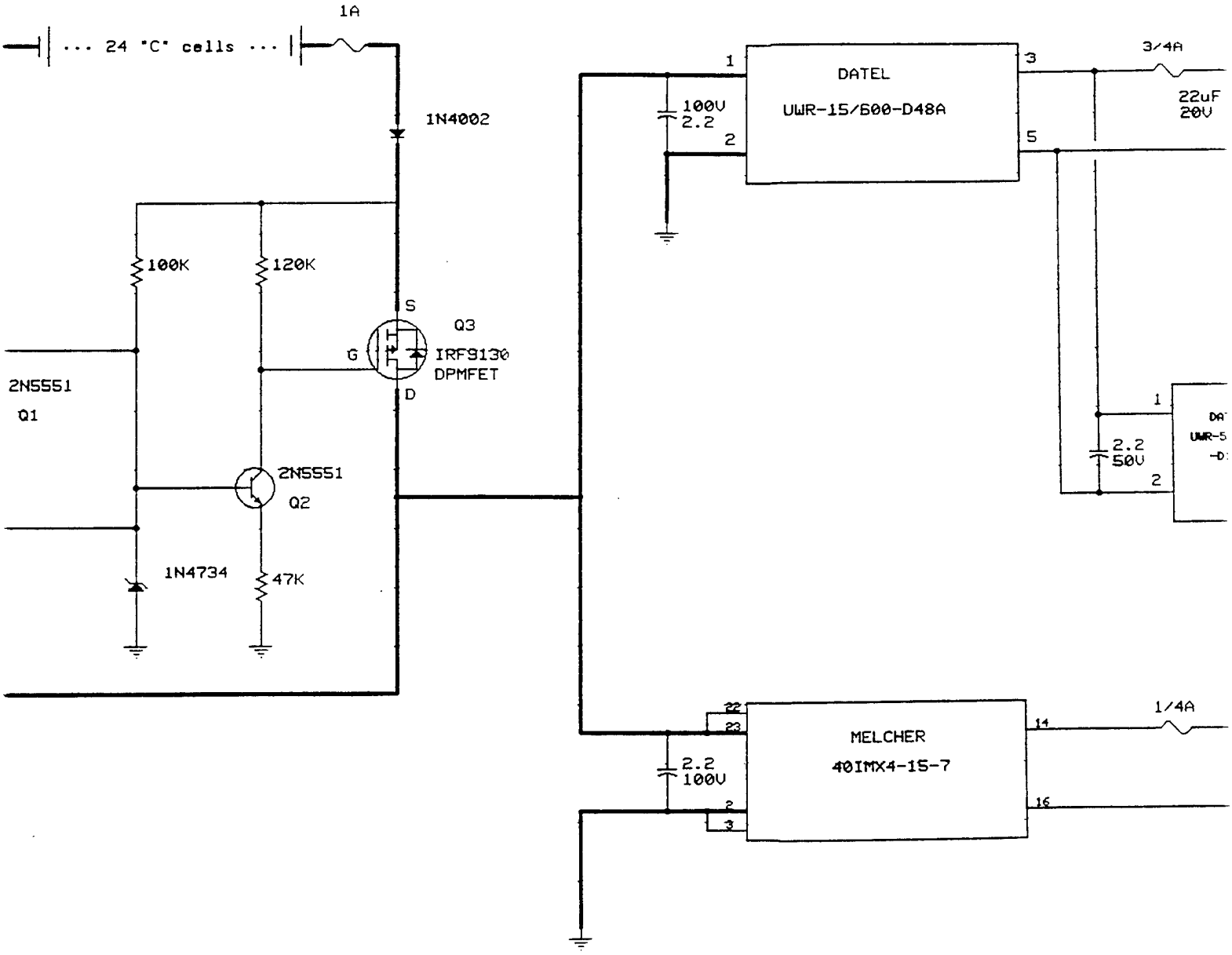
8. User Interface Document, GG1320AN Dig-Gyro Ring Laser Gyro, Honeywell Avionics Division, Specification Number ED7165-01, Cage Code 94580, Minneapolis, MN, 1997.

4.2 Chassis Wiring Block Diagram: Figure [12]





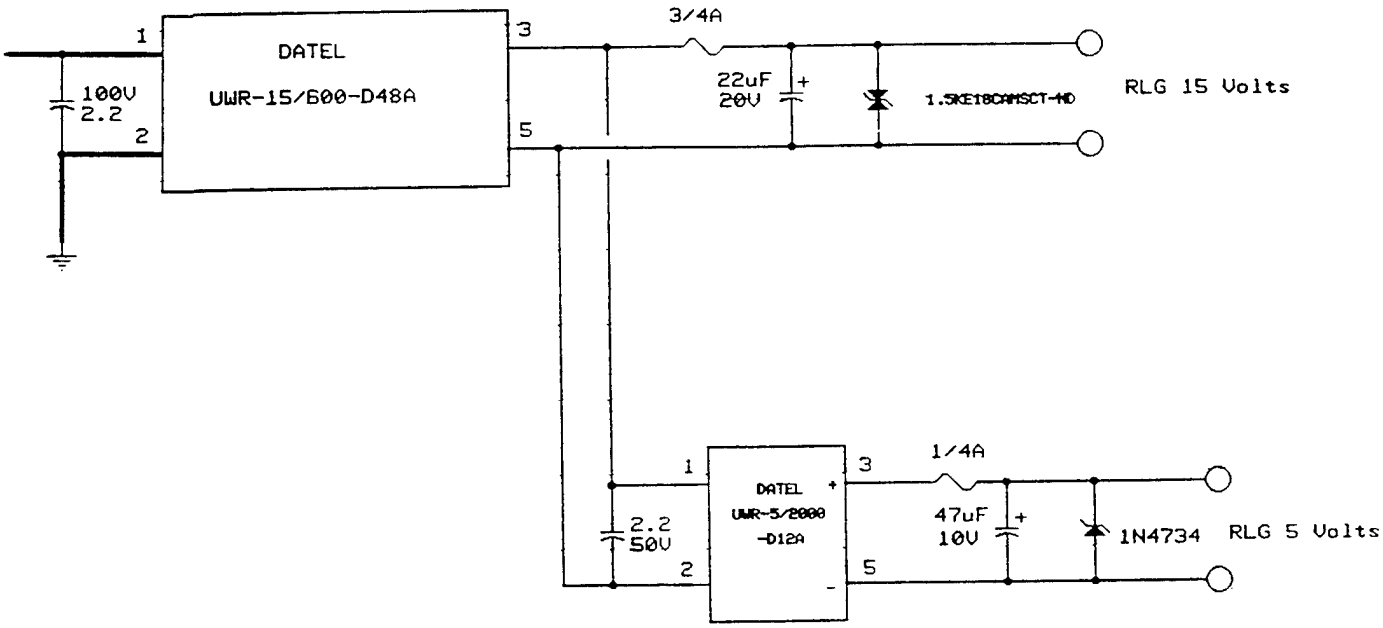
Note: 1) Capacitance in uF.
2) Fuses are PICO II series 251
3) Mount capacitors as close to converters as possible
4) Short J1 pin 1 to pin 3 to shut down system.

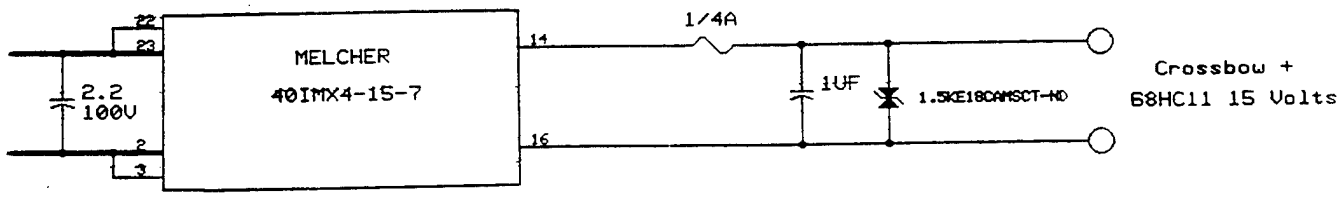


possible

(2)

Woods Hole Oceanographic Ir
Woods Hole, Mass 025
Proj. 810512.03 By Steve L
Sheet 1 of 1 Date 25





Woods Hole Oceanographic Institution Woods Hole, Mass 02543 Proj. 810512.03 By Steve Liberatore Sheet 1 of 1 Date 25 Mar. 1998	Title Ring Laser Gyro Power Interface Circuit

(3)

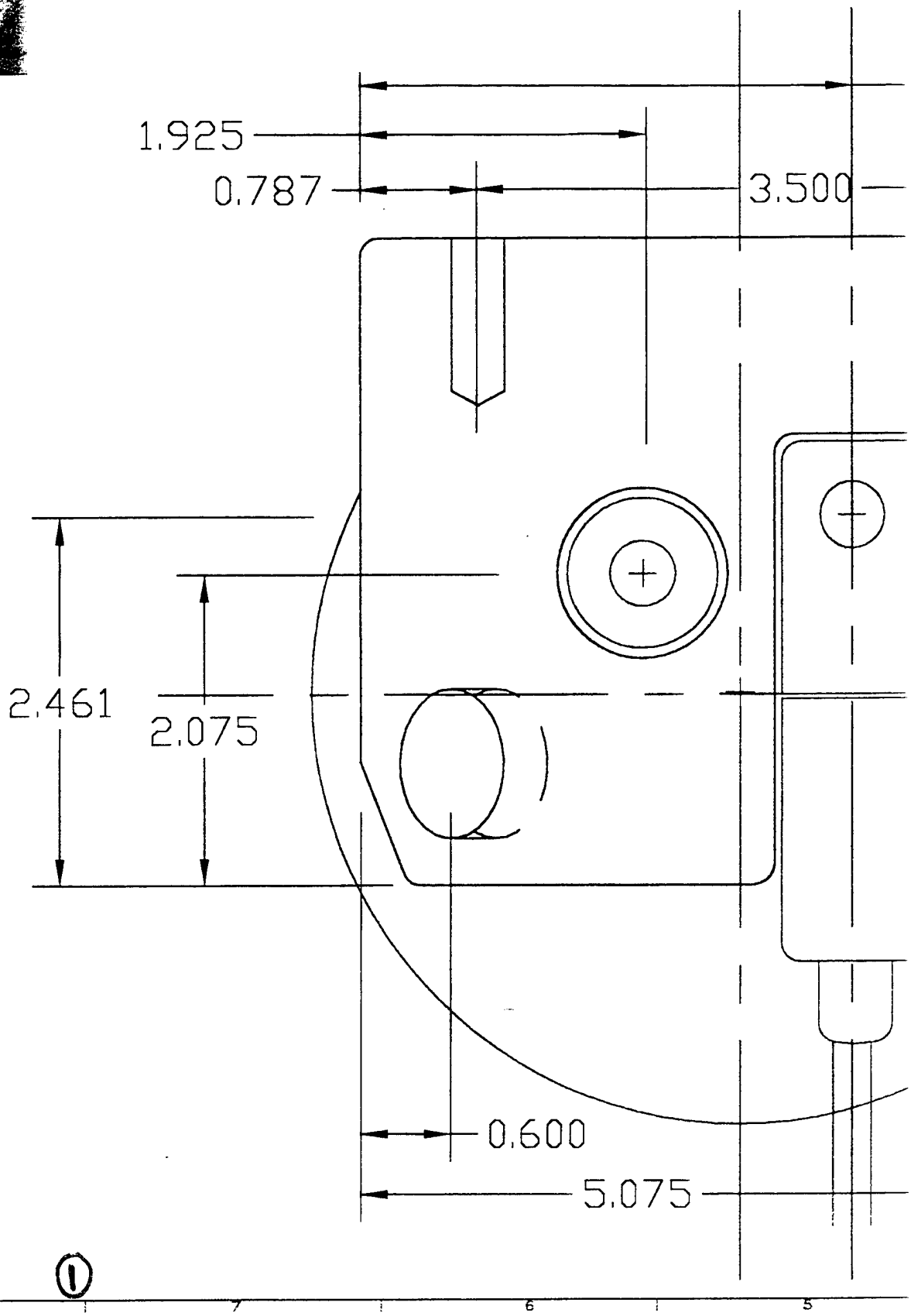
6.0 Mechanical Drawings

RLG-98-010	Endcap and Connector Guard	16
RLG-98-011	Connector Guard Detail	17
RLG-98-012	Housing Bell Mount	18
RLG-98-016	Housing Bell	19
RLG-98-017	Endcap	20
RLG-98-018	Crossbow Mounting Plate	21
RLG-98-020	PCB Spreader	22
RLG-98-021	Transfer Plate	23
RLG-98-022	Sensor Stack Spacer	24
RLG-98-025	Battery Pack Plate	25

Acknowledgements

My special thanks to Tim Thiel, Steve Liberatore, Bob McCabe, Barrie Walden, Don Peters, Glenn McDonald, Albert Bradley, Jia Qin Zhang, Hanumant Singh and Dana Yoerger for their help during the performance of this project.

Dynamic Systems Laboratory
DSL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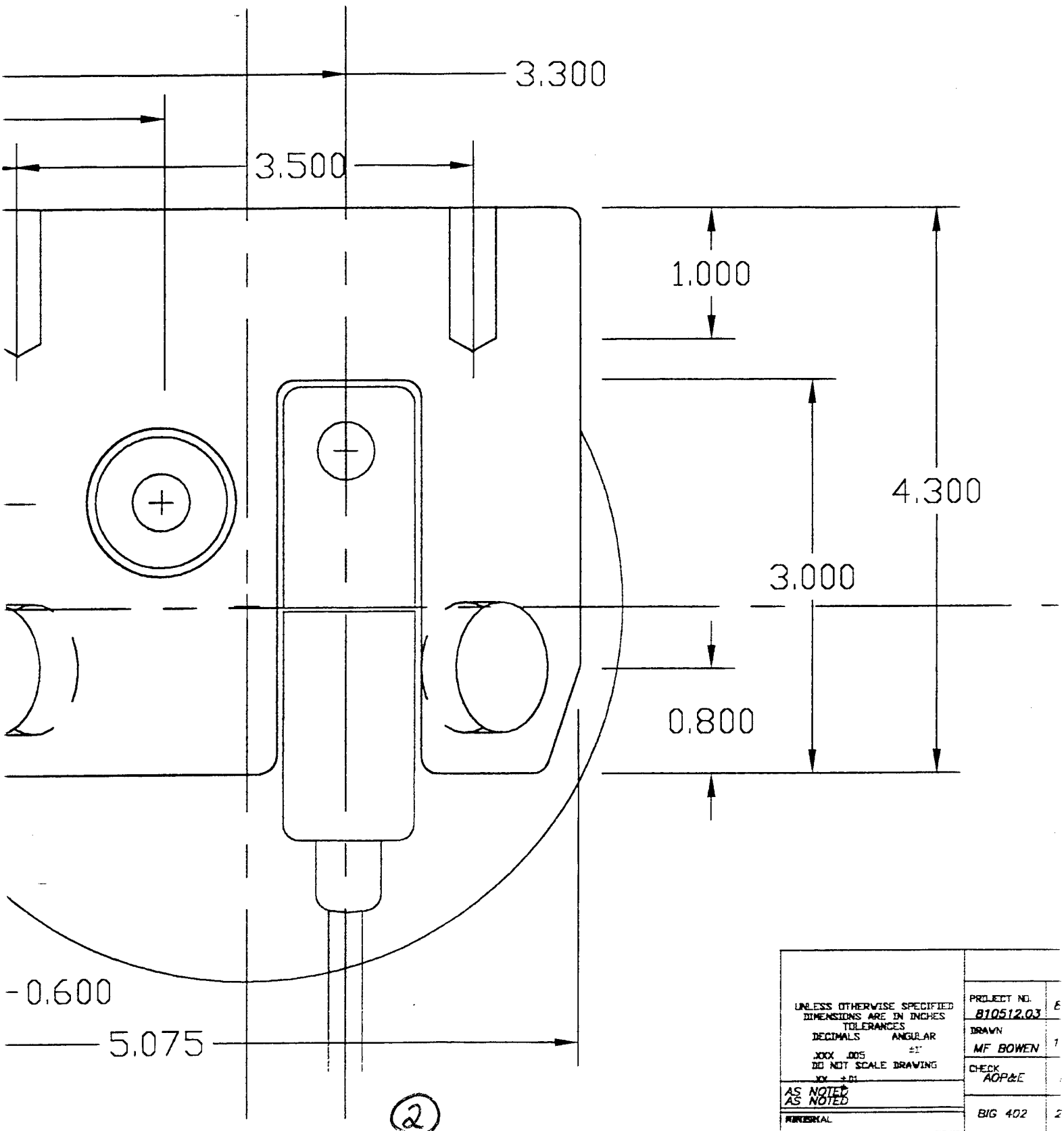
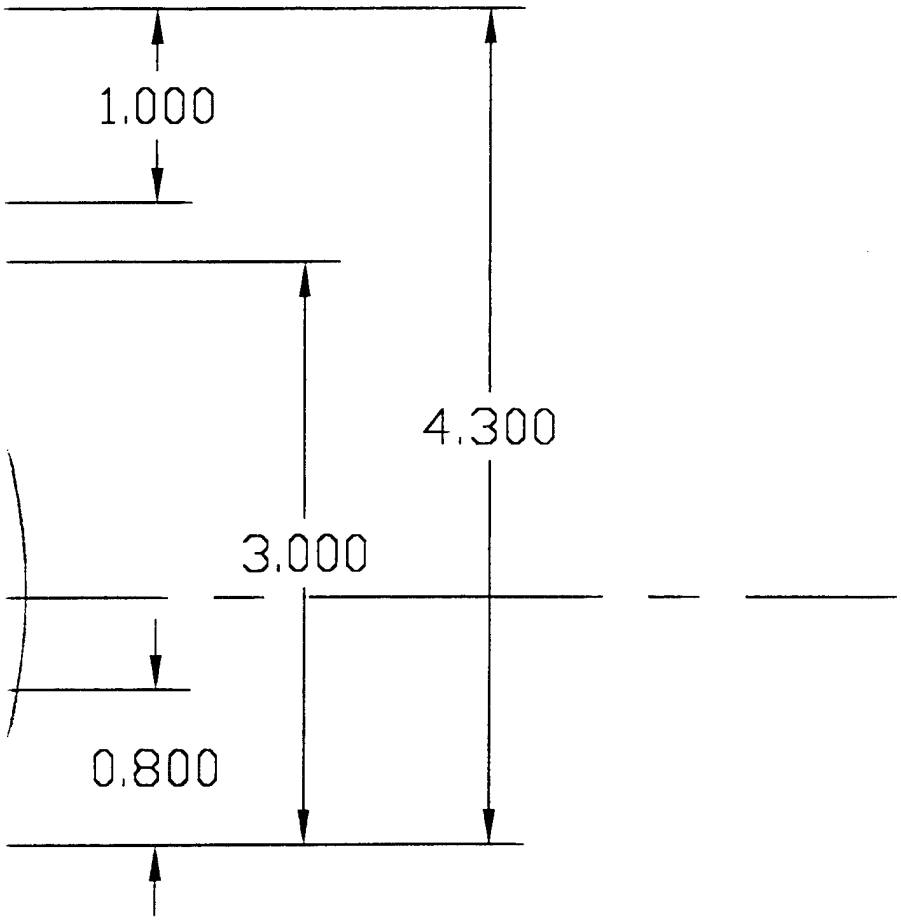
3.500
2.461
2.075
0.600
5.075

(1)



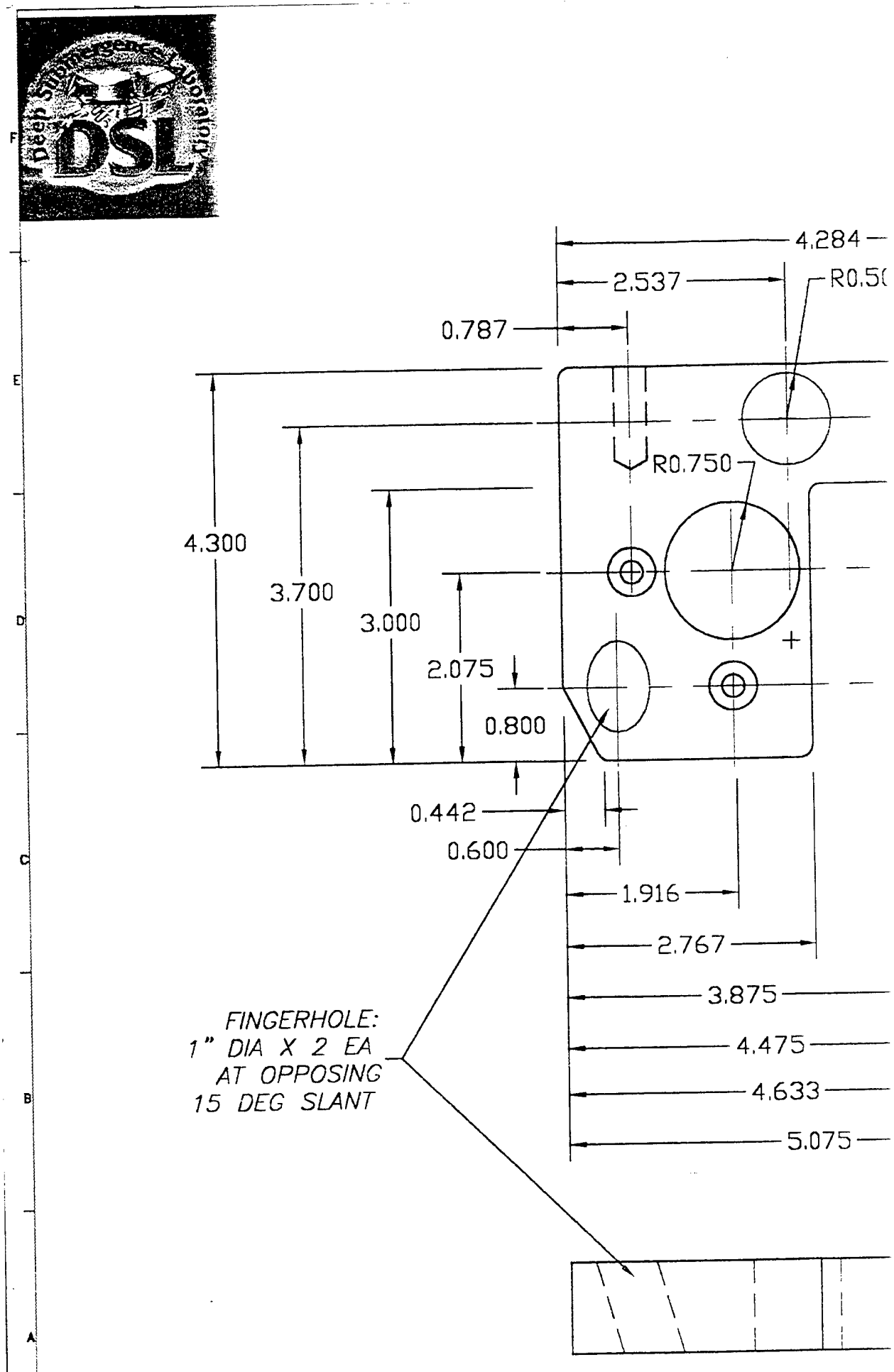
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XXX .005 ±1° DO NOT SCALE DRAWING .XX ±.01	PROJECT NO. 810512.03
	DRAWN MF BOWEN
	CHECK AOP&E
AS NOTED AS NOTED	BIG 402
MATERIAL	

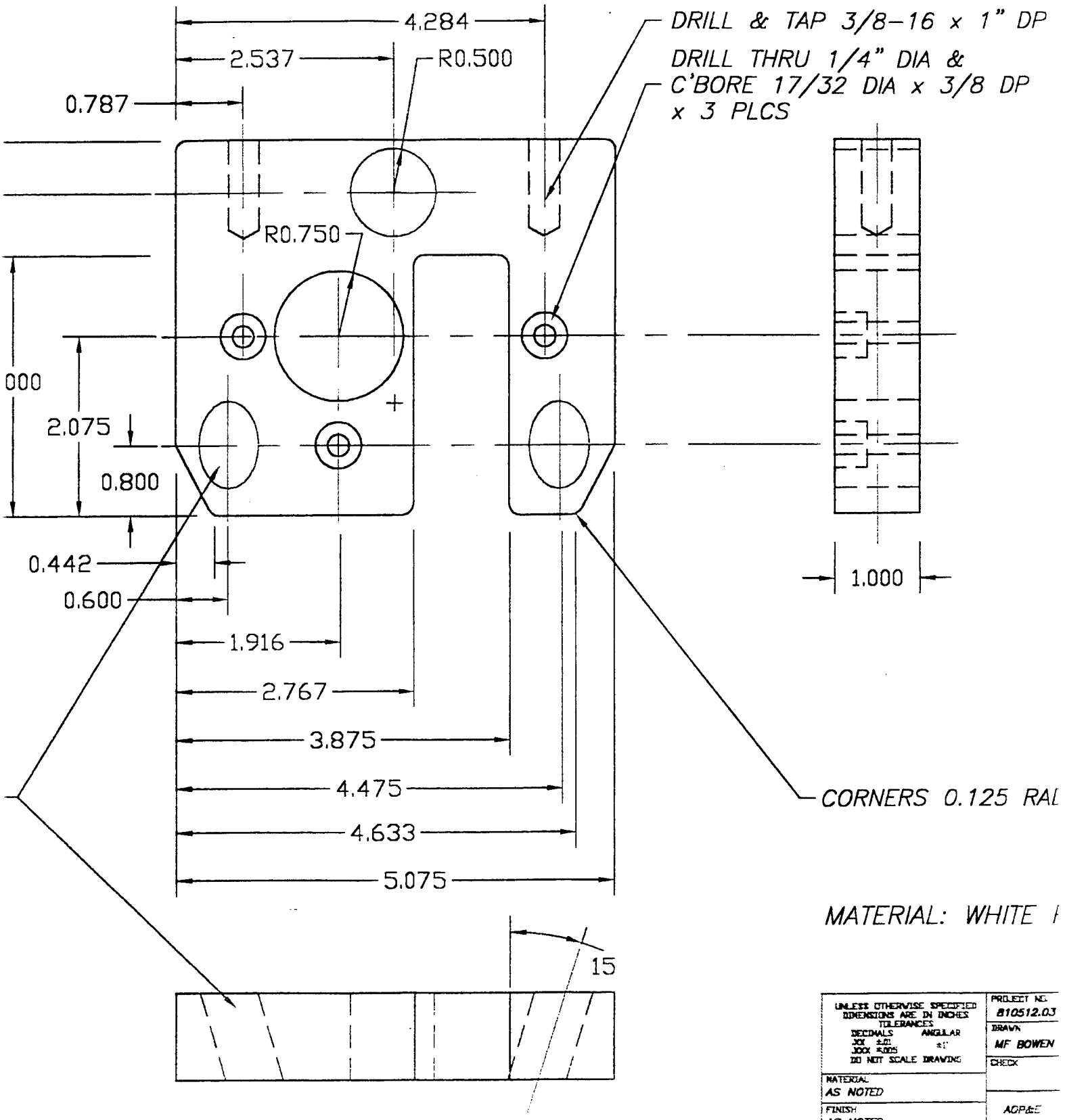
(2)

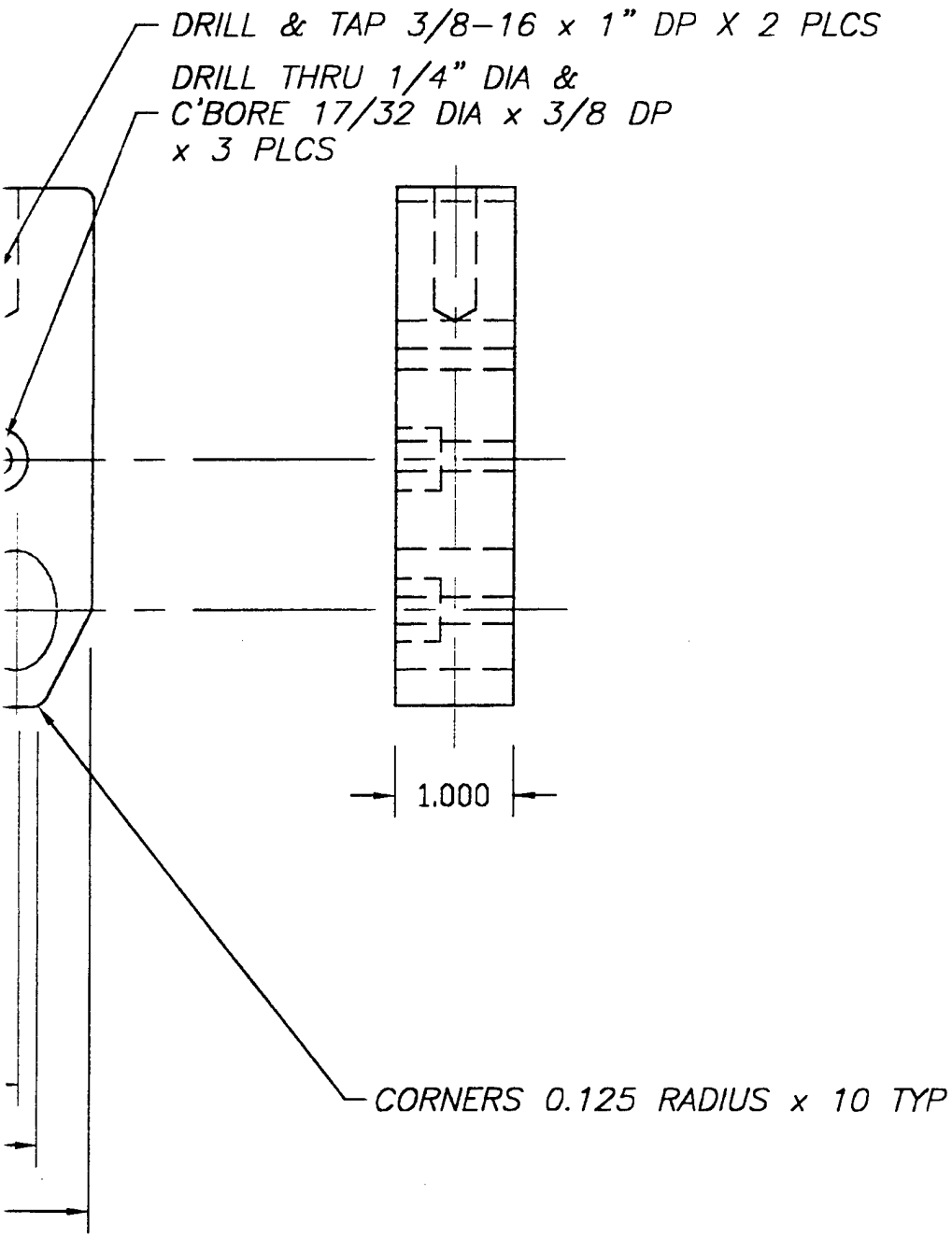


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XXX .005 ±1° DO NOT SCALE DRAWING .XX ±.01		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543	
AS NOTED AS NOTED	PROJECT NO. 810512.03	DATE 8MAR98	TITLE ENDCAP AND CONN GUARD RING LASER GYRO
	DRAWN MF BOWEN	11 x 17	
	CHECK AOP&E	MS #9	SIZE B 16 DWG NO. RLG-98-010
MATERIAL	BIG 402	289-3420	SCALE NONE RELEASE DATE SHEET OF

(3)


4.284
2.537
R0.5(
0.787
R0.750
4.300
3.700
3.000
2.075
0.800
0.442
0.600
1.916
2.767
3.875
4.475
4.633
5.075
FINGERHOLE:
1" DIA X 2 EA
AT OPPOSING
15 DEG SLANT


4.284
2.537
R0.500
0.787
DRILL & TAP 3/8-16 x 1" DP
DRILL THRU 1/4" DIA &
C'BORE 17/32 DIA x 3/8 DP
x 3 PLCS
R0.750
000
2.075
0.800
0.442
0.600
1.916
2.767
3.875
4.475
4.633
5.075
1.000
CORNERS 0.125 RAI
MATERIAL: WHITE
15
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS ANGULAR
XX ±.01 ±1°
XXX ±.005
DO NOT SCALE DRAWING
PROJECT NO.
810512.03
DRAWN
MF BOWEN
CHECK
MATERIAL
AS NOTED
FINISH
AS NOTED
AGP&E
BIG 402
2
6
5
4
3

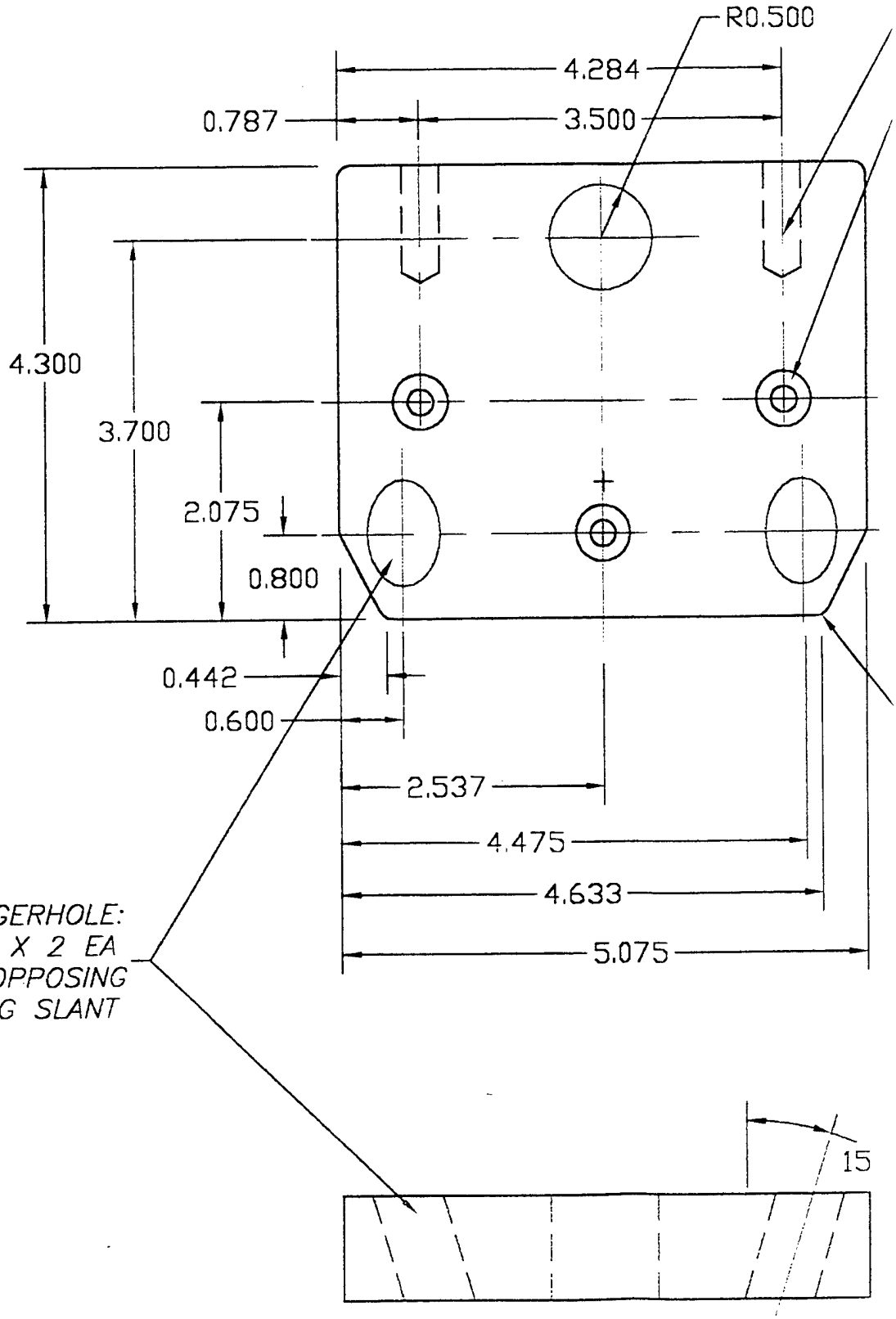


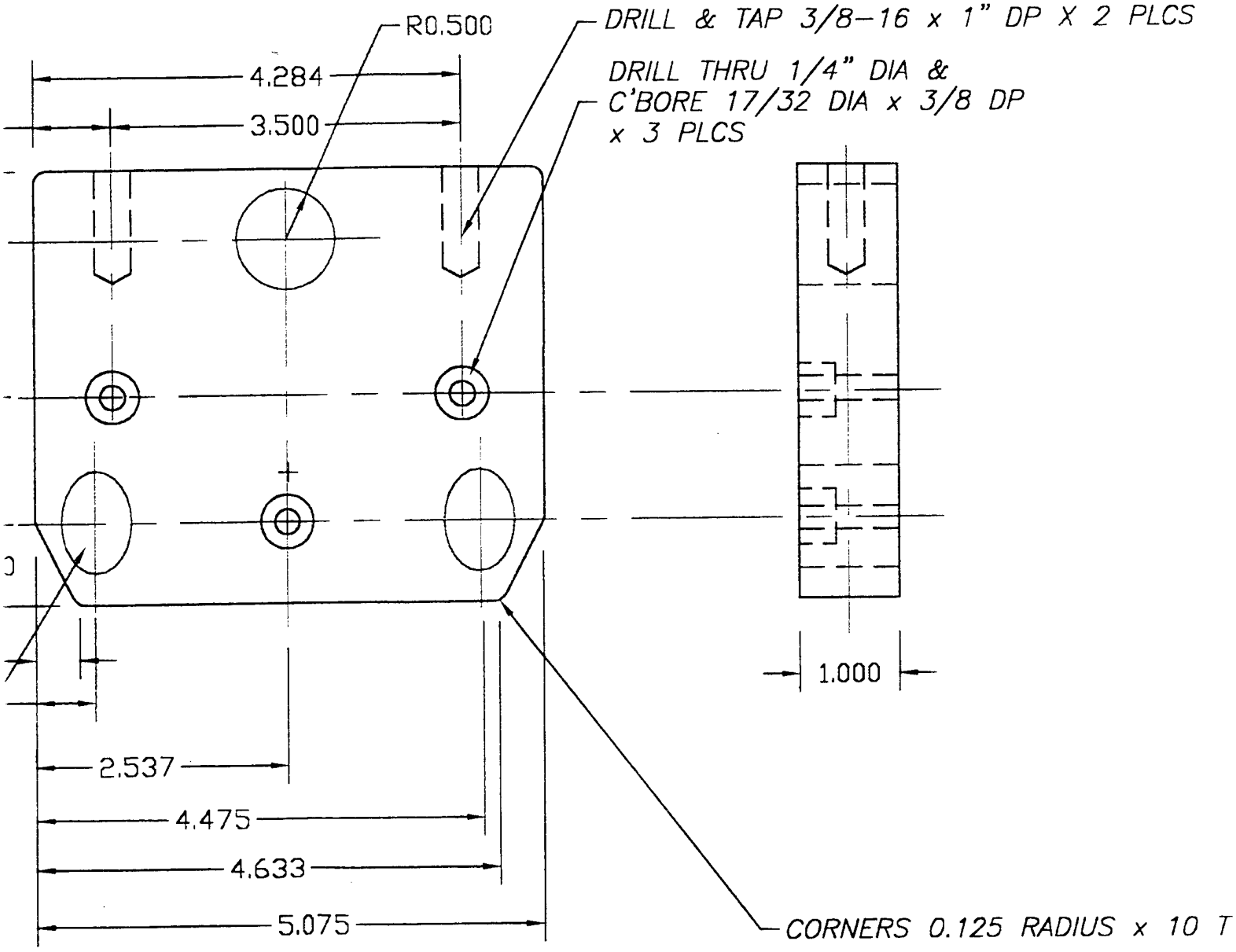
MATERIAL: WHITE POLYETHYLENE

15

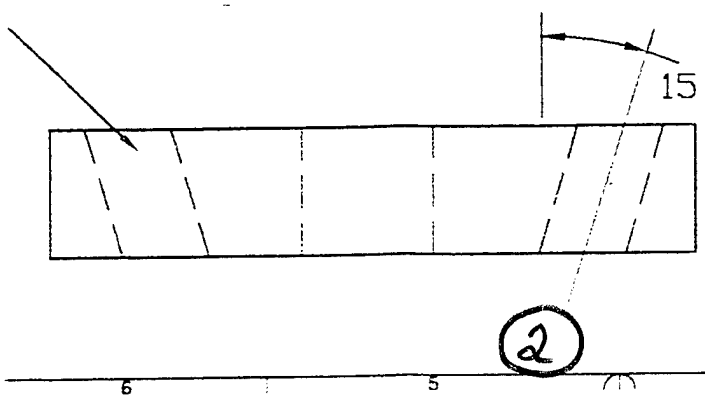
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS XX ±.01 XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. B10512.03	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543	
	DRAWN MF BOWEN	DATE 09 MAR 98	TITLE CONNECTOR GUARD RING LASER GYRO
	CHECK	17 x 22	
MATERIAL AS NOTED	AOP&E	MS #9	SIZE C 17 DWG NO. RLG-98-011
FINISH AS NOTED	BIG 402	289-3420	SCALE NONE RELEASE DATE SHEET OF

(3)


R0.500
4.284
0.787
3.500
4.300
3.700
2.075
0.800
0.442
0.600
2.537
4.475
4.633
5.075
FINGERHOLE:
1" DIA X 2 EA
AT OPPOSING
15 DEG SLANT
15



MATERIAL: WHITE POLYETHYLE

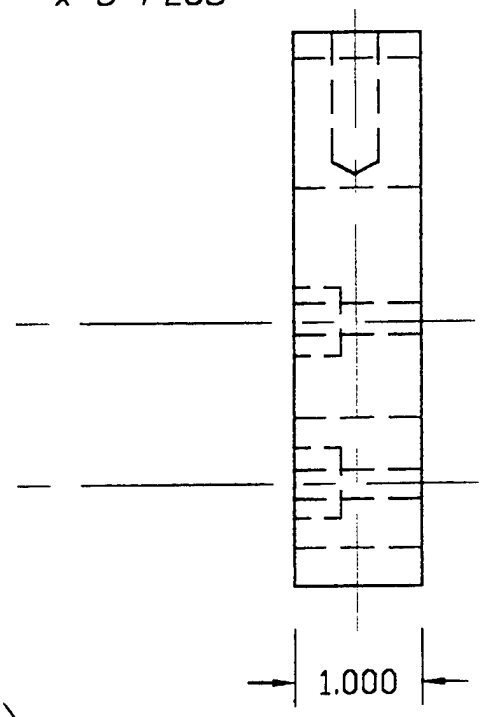


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03		WOODS APPLIED
	DRAWN MF BOWEN	DATE 09 MAR 98	TITLE H
	CHECK	17 x 22	
MATERIAL AS NOTED	AOP&E	MS #9	SIZE C 18
FINISH AS NOTED	BIG 402	289–3420	SCALE NONE

6 5 4 3 2

DRILL & TAP 3/8–16 x 1" DP X 2 PLCS

DRILL THRU 1/4" DIA &
C'BORE 17/32 DIA x 3/8 DP
x 3 PLCS

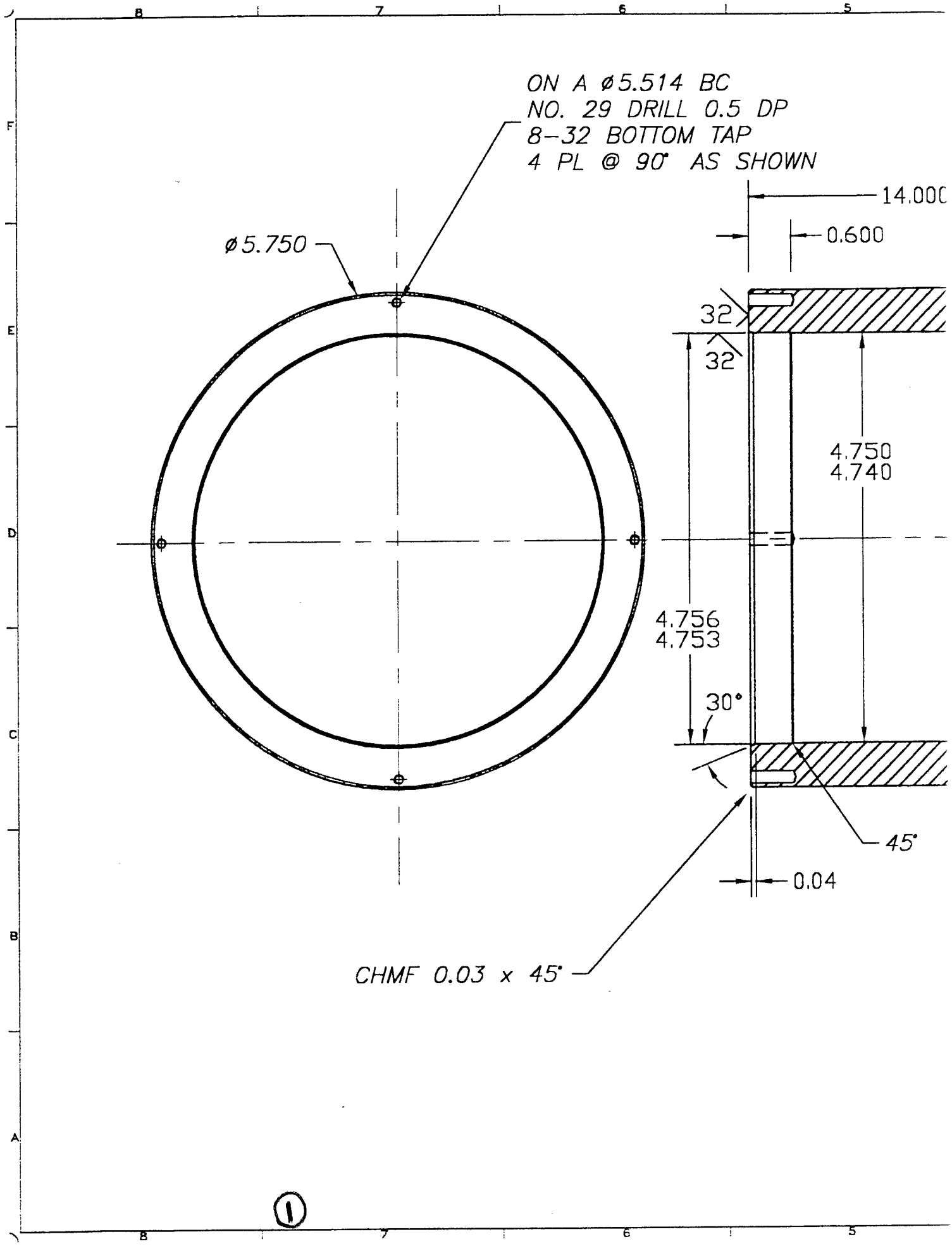


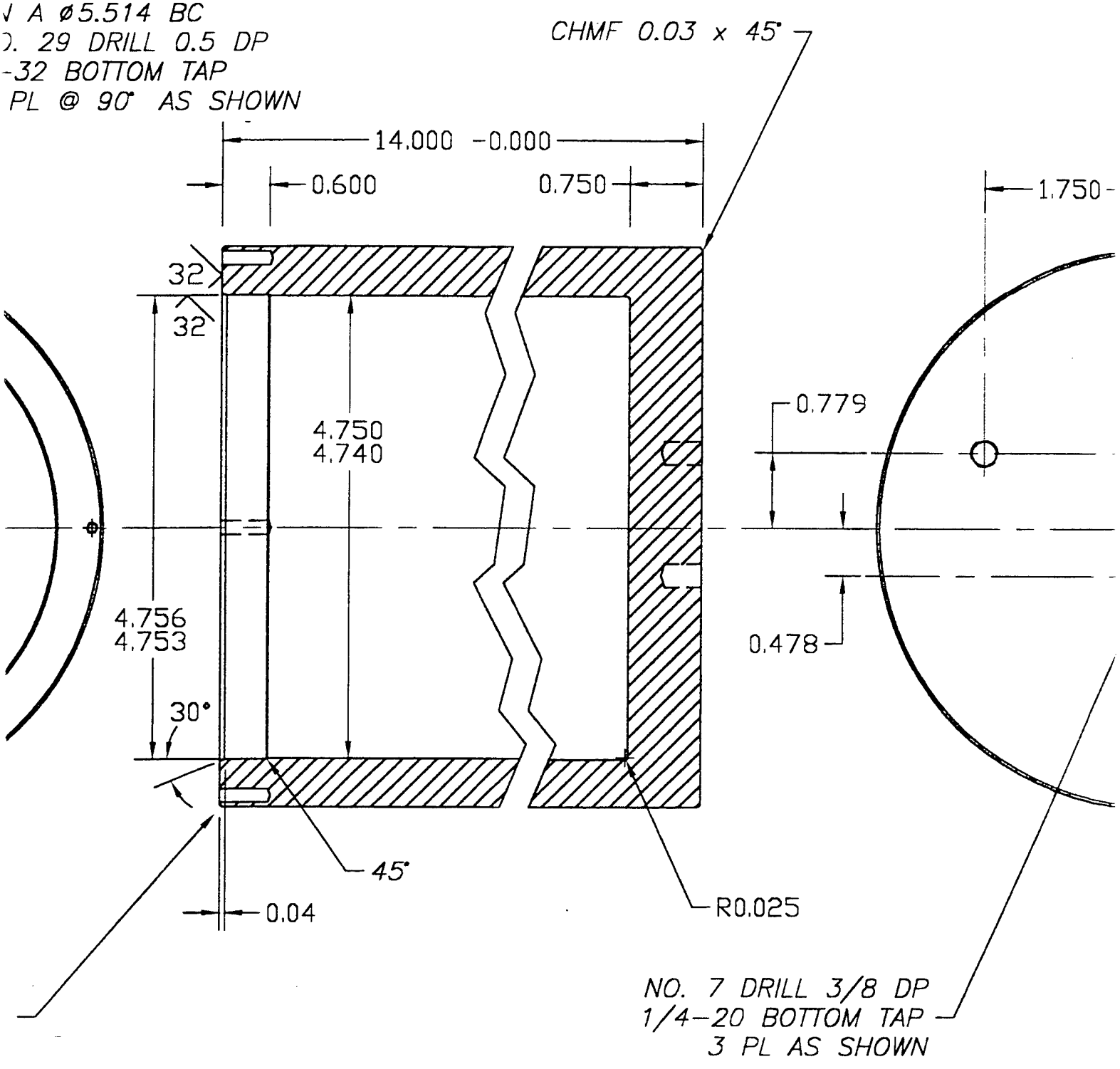
CORNERS 0.125 RADIUS x 10 TYP

MATERIAL: WHITE POLYETHYLENE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XX ±.01 ±1° .XXX ±.005 DO NOT SCALE DRAWING	PROJECT NO. 810512.03	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543	
	DRAWN MF BOWEN / DATE 09 MAR 98	TITLE HOUSING BELL MOUNT RING LASER GYRO	
	CHECK / 17 x 22		
MATERIAL AS NOTED	AOP&E / MS #9	SIZE C / 18	DWG NO. RLG–98–012
FINISH AS NOTED	BIG 402 / 289–3420	SCALE NONE / RELEASE DATE	SHEET OF

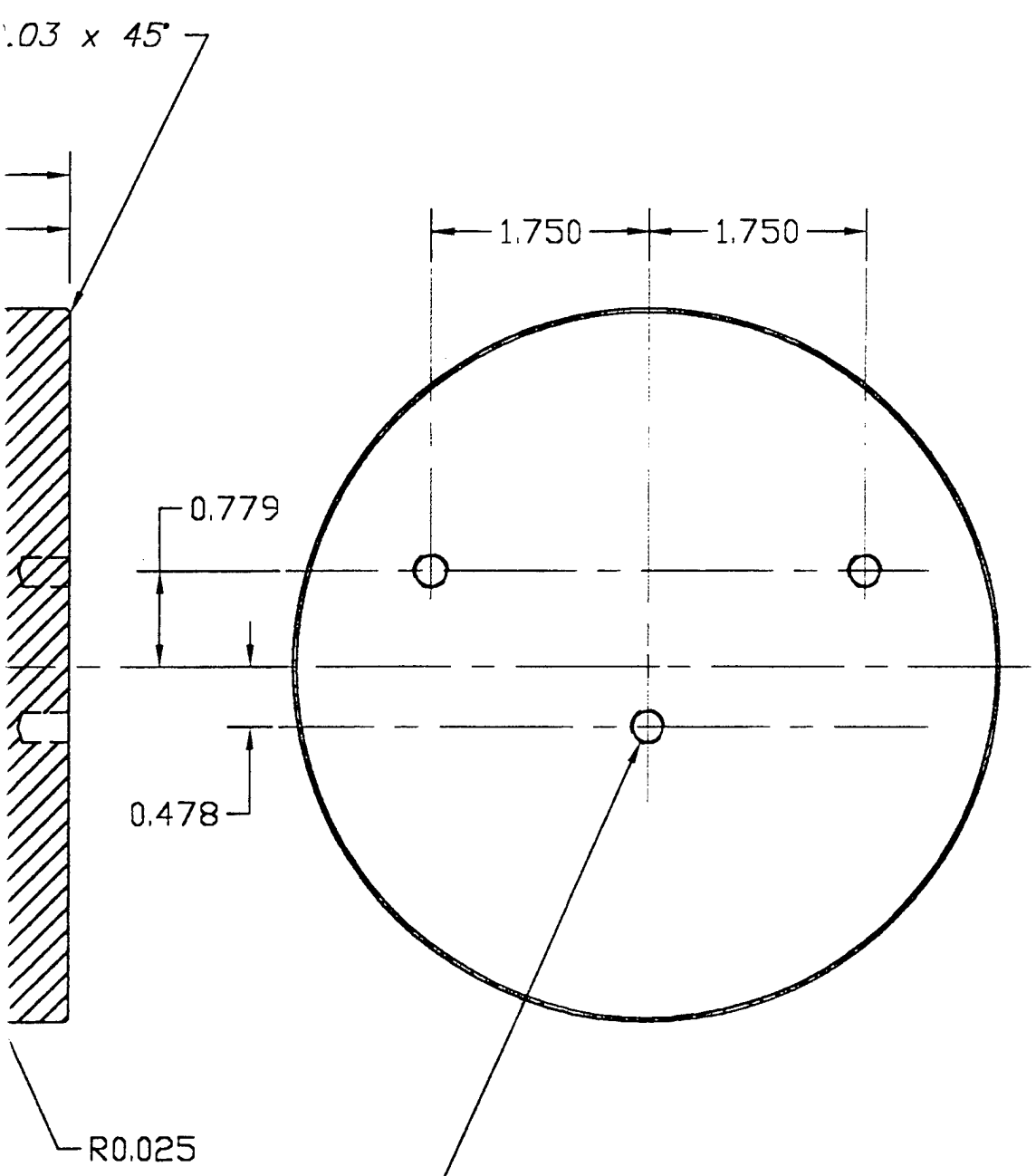
(3)


ON A ø5.514 BC
NO. 29 DRILL 0.5 DP
8-32 BOTTOM TAP
4 PL @ 90° AS SHOWN
ø5.750
14.000
0.600
32
32
4.750
4.740
4.756
4.753
30°
45°
0.04
CHMF 0.03 x 45°
B
7
6
5
F
E
D
C
B
A
1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03
	DRAWN MF BOWEN
	CHECK
MATERIAL AS NOTED	
FINISH AS NOTED	AOP&E
	BIG 402

(2)

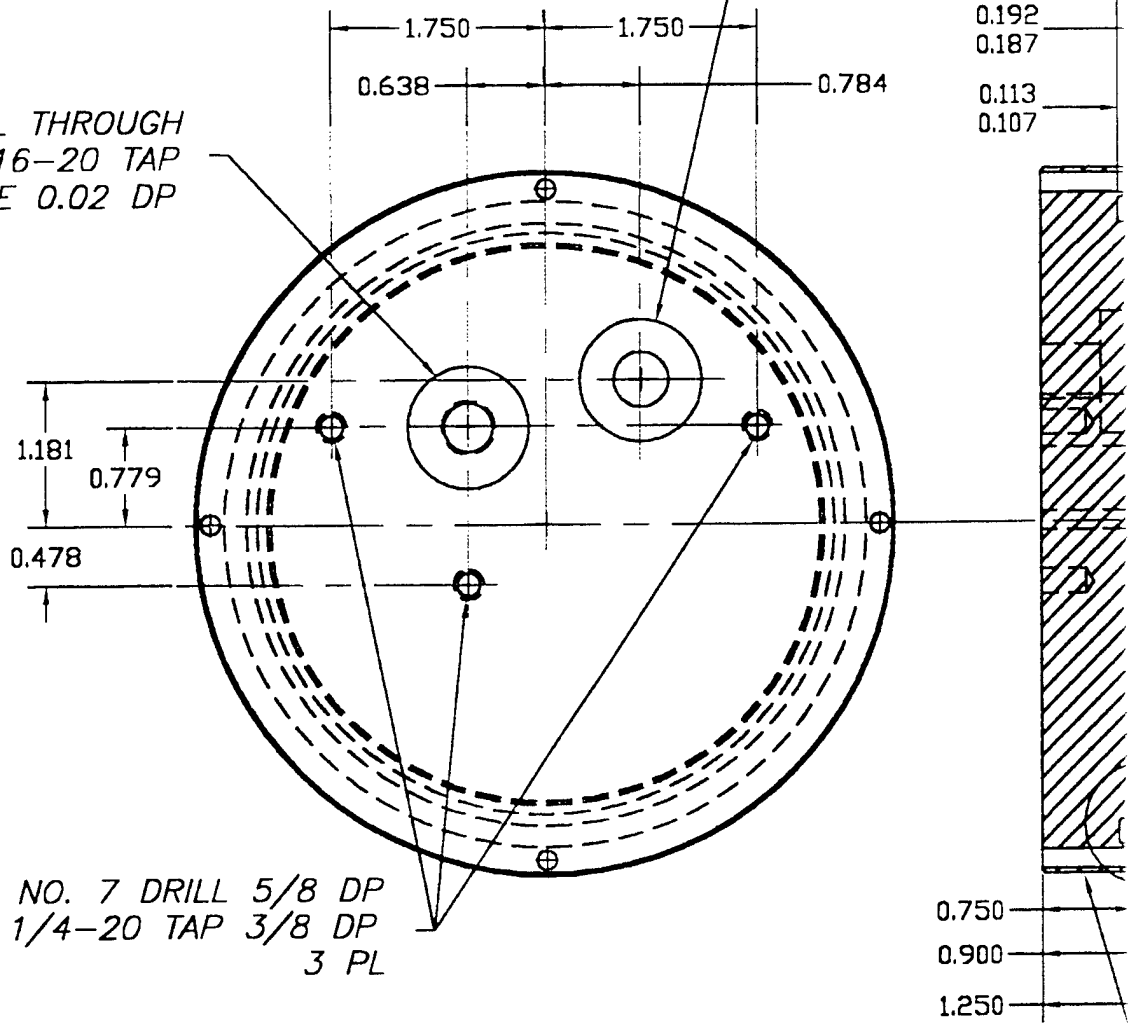


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 16 MAR 98	TITLE HOUSING BELL RING LASER GYRO
	CHECK	11 x 17	
MATERIAL AS NOTED	AOP&E	MS #9	SIZE B 19 DWG NO. RLG-98-016
FINISH AS NOTED	BIG 402	289-3420	SCALE NONE RELEASE DATE SHEET OF

(3)

29/64 DRILL THROU
ø1.0 SPOTFACE 0.02

25/64 DRILL THROUGH
7/16–20 TAP
ø1.0 SPOTFACE 0.02 DP



NO. 7 DRILL 5/8 DP
1/4–20 TAP 3/8 DP
3 PL

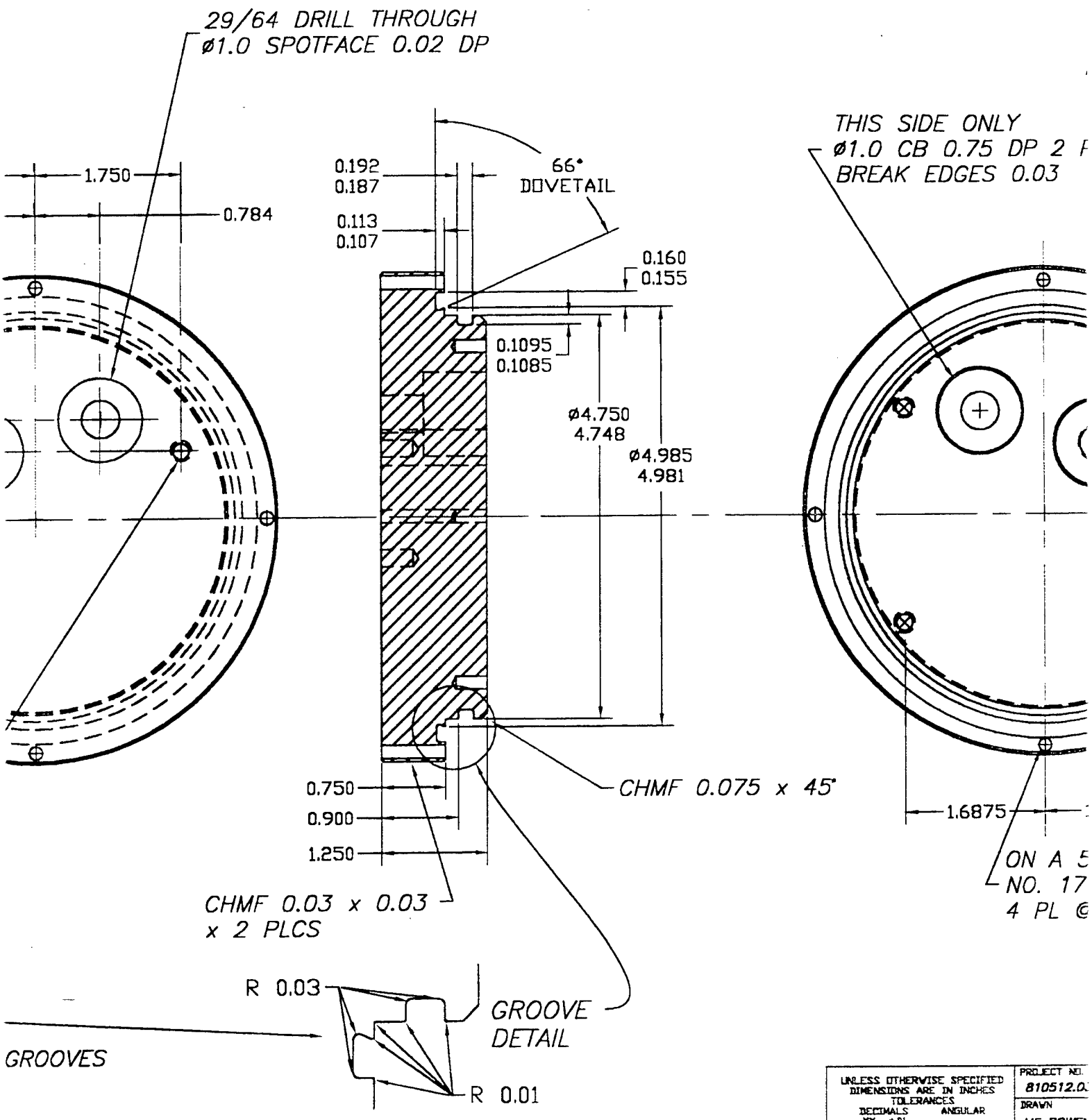
CHMF 0.03 x 0.03
x 2 PLCS

R 0.03

NOTE A

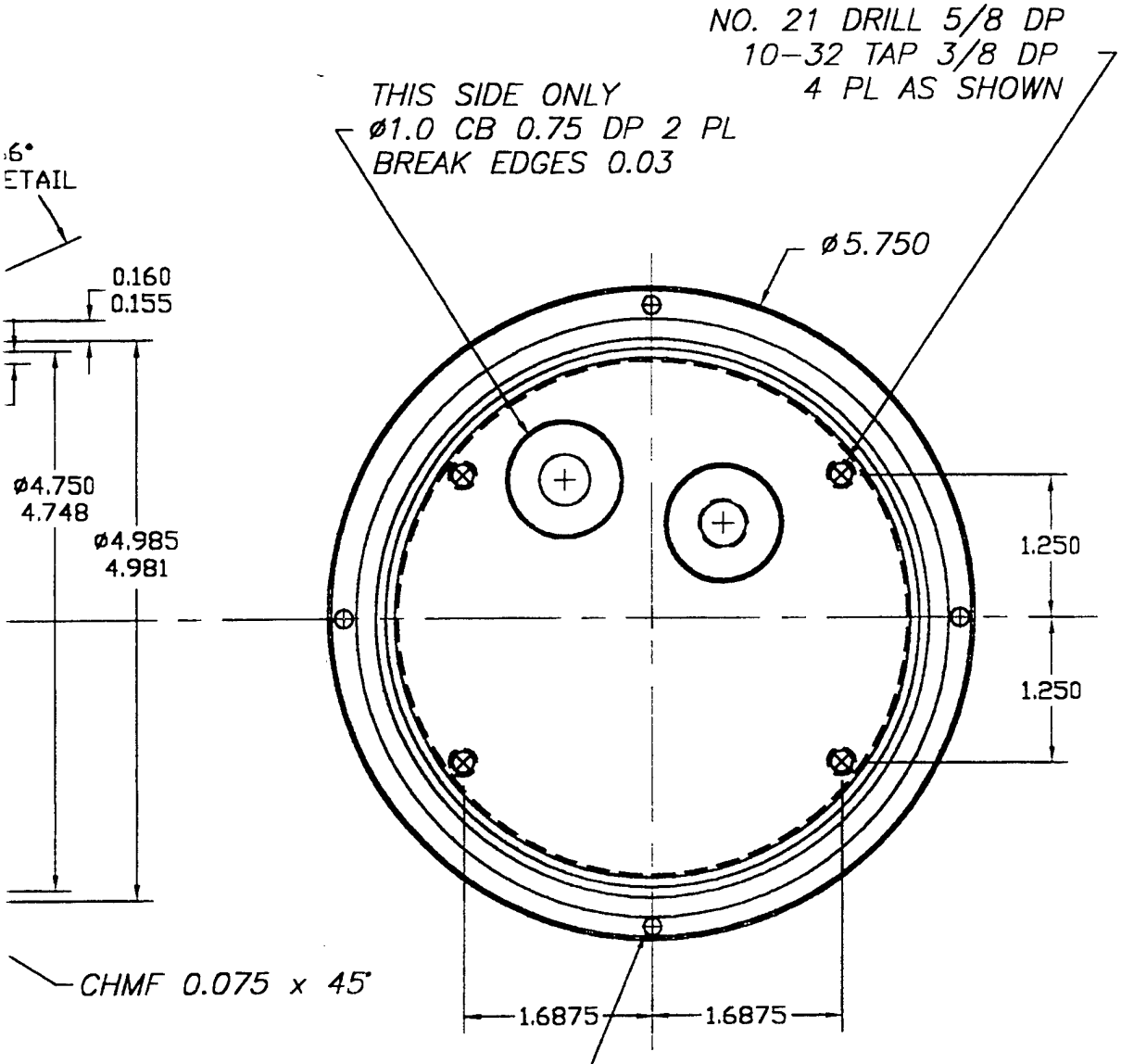
2–246 & 2–249 O–RING GROOVES
FINISH 32 RMS

(1)



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XX ±.01 ±1° .XXX ±.005 DO NOT SCALE DRAWING	PROJECT NO. 810512.0
	DRAWN MF BOWEN
	CHECK
MATERIAL TITANIUM 6AL-4V	
FINISH AS NOTED	AOP&E
	BIG 402

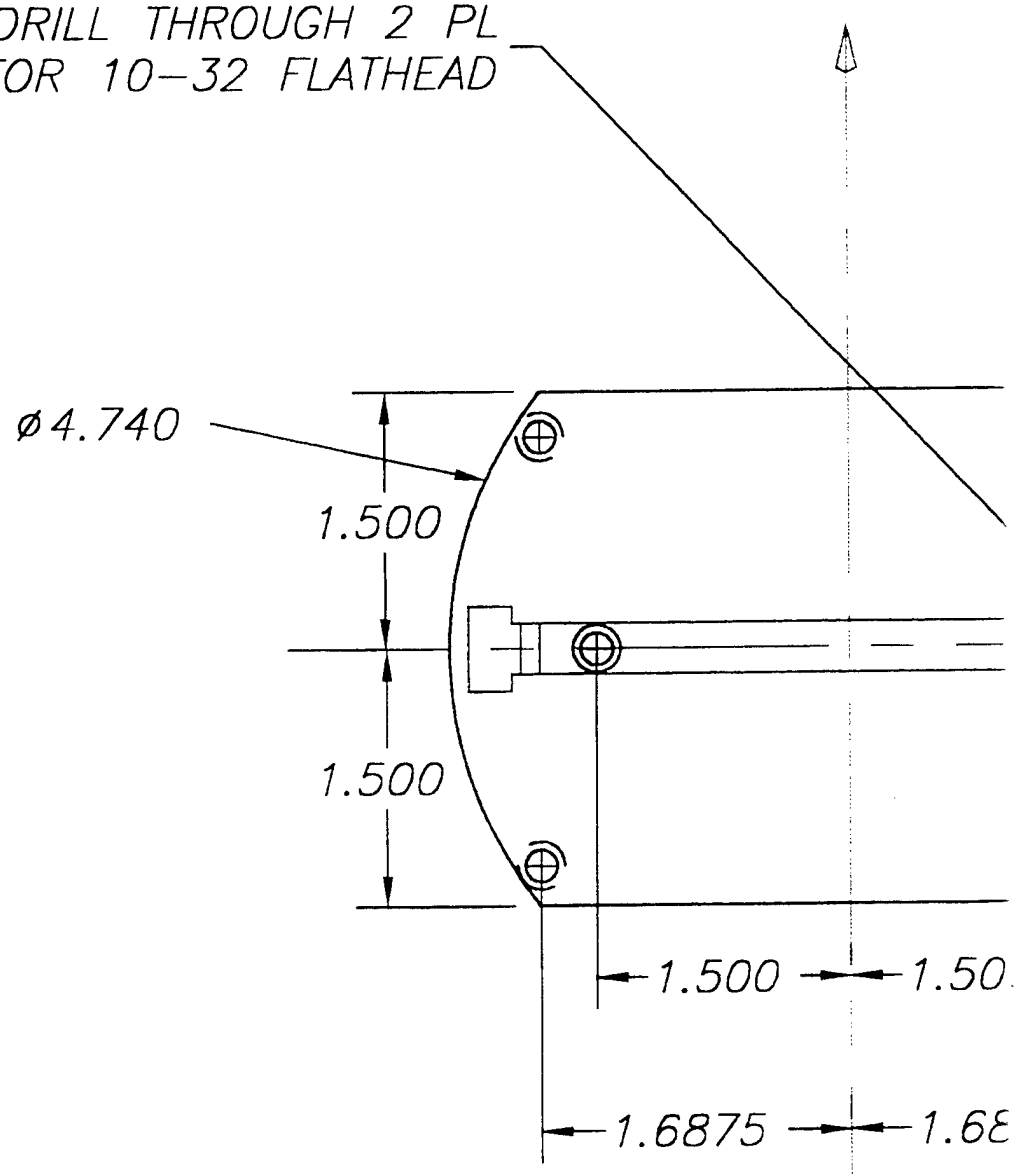
(2)



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543	
	DRAWN MF BOWEN	DATE 17 MAR 98	TITLE ENDCAP RING LASER GYRO HOUSING
	CHECK	11 x 17	
MATERIAL TITANIUM 6AL-4V			
FINISH AS NOTED	AOP&E	MS #9	SIZE B 20 DWG NO. RLG-98-017
	BIG 402	289-3420	SCALE NONE RELEASE DATE SHEET OF

(3)

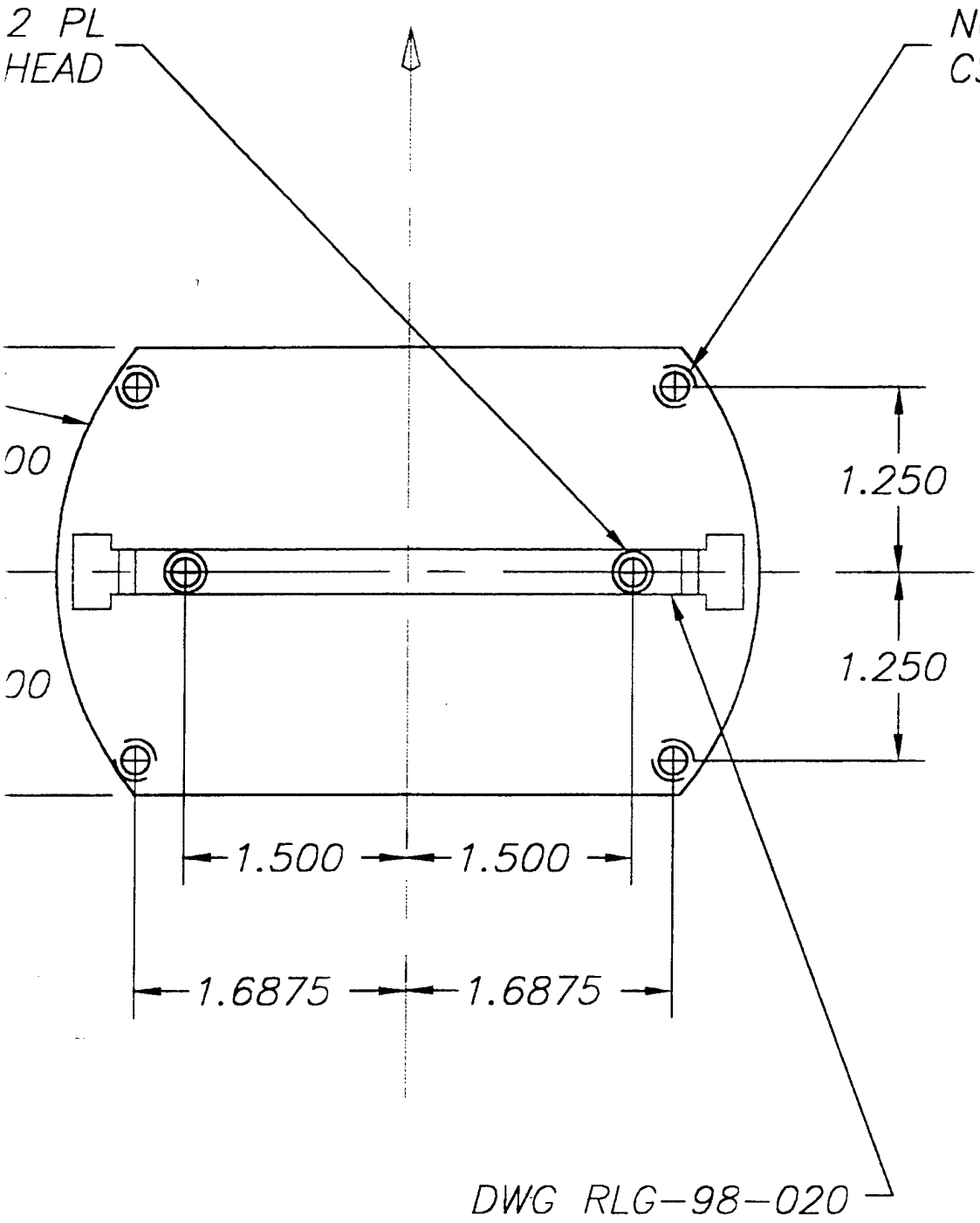
NO. 9 DRILL THROUGH 2 PL
CS THIS SIDE FOR 10-32 FLATHEAD



NB: TOP VIEW

DWG

①



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03
	DRAWN MF BOWEN
	CHECK
MATERIAL ALUMINUM 5052 SHEET	
FINISH AS NOTED	AOP&E
	BIG 402

(2)

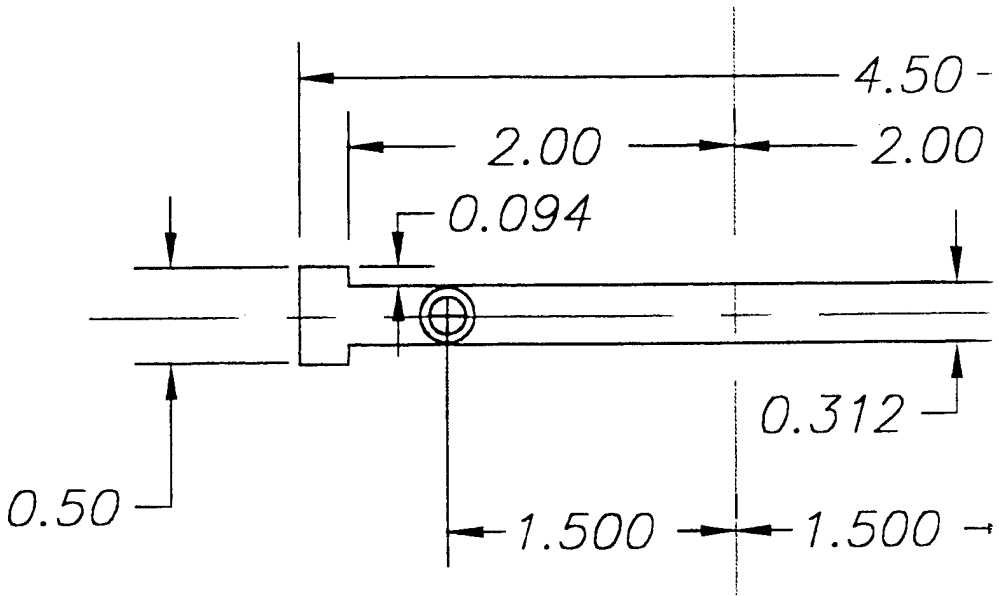
NO. 9 DRILL THROUGH 4 PL
CS OTHER SIDE FOR 10-32 FLATHEAD

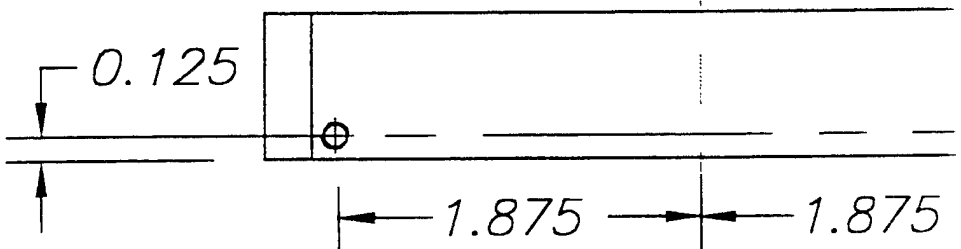
CHMF 0.01 X 0.01
2 EDGES

-020

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 16 MAR 98	TITLE XBOW MNTNG PLATE RING LASER GYRO
	CHECK	11 x 17	
MATERIAL ALUMINUM 5052 SHEET			
FINISH AS NOTED	AOP&E	MS #9	SIZE B 21 DWG NO. RLG-98-018
	BIG 402	289-3420	SCALE NONE RELEASE DATE SHEET OF

(3)





2EA REQ'D

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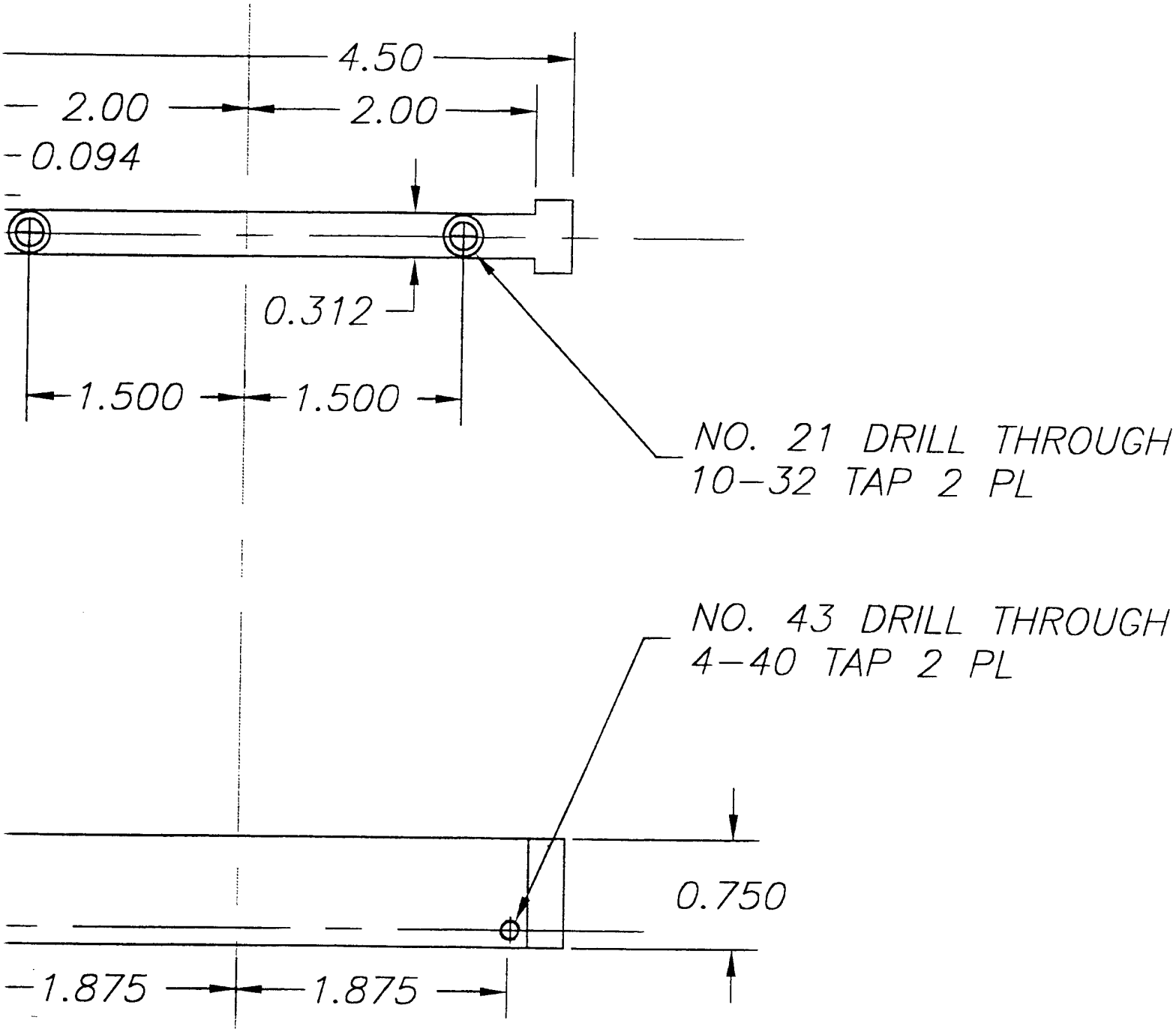


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XX ±.01 .XXX ±.005 ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03
	DRAWN MF BOWEN 23
	CHECK 11
MATERIAL BLACK DELRIN	
FINISH AS NOTED	AOP&E M:
	BIG 402 28:

(2)

NO. 21 DRILL THROUGH
10-32 TAP 2 PL

NO. 43 DRILL THROUGH
4-40 TAP 2 PL

0.750

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMALS XX ±.01 XXX ±.005
ANGULAR ±1°
DO NOT SCALE DRAWING

MATERIAL: BLACK DELRIN

FINISH: AS NOTED

(3)

PROJECT NO. 810512.03

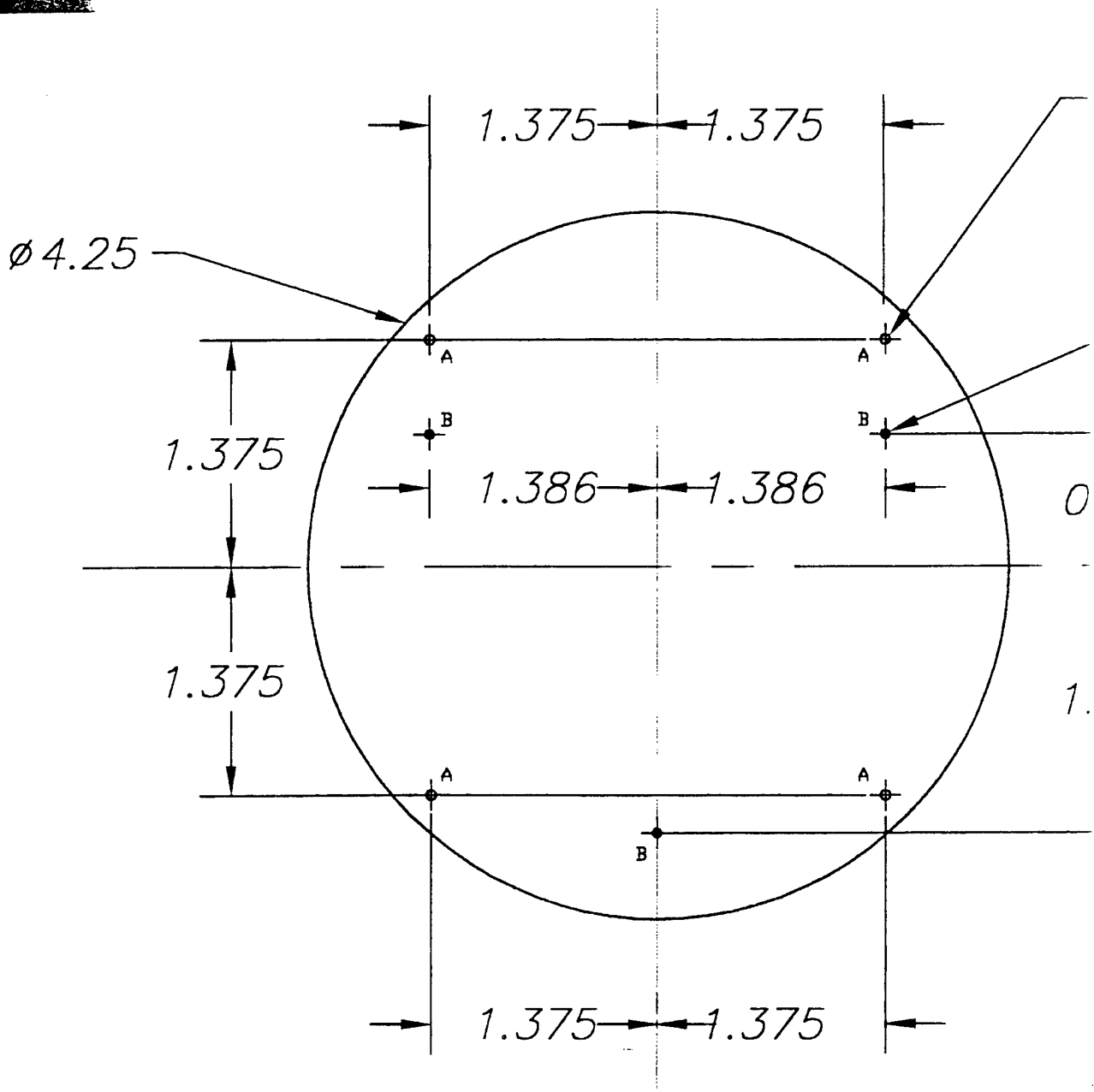
DRAWN	DATE
MF BOWEN	23 MAR 98
CHECK	
	11 x 17
AOP&E	MS #9
BIG 402	289-3420

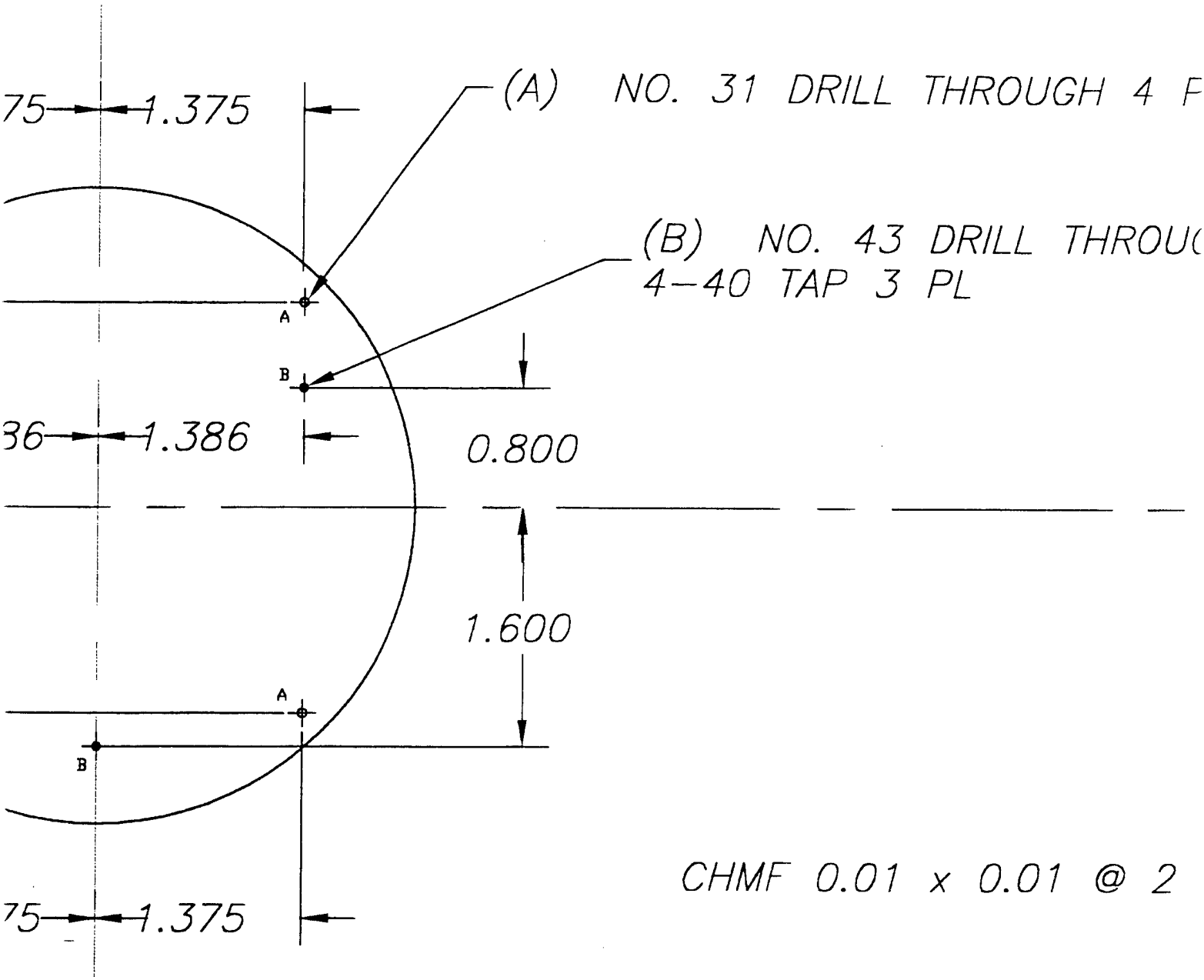
WOODS HOLE OCEANOGRAPHIC INSTITUTION
APPLIED OCEAN PHYSICS & ENGINEERING
WOODS HOLE, MASSACHUSETTS, 02543

TITLE
PCB SPREADER
RING LASER GYRO

SIZE		DWG NO.
B	22	RLG-98-020

SCALE	NONE	RELEASE DATE	SHEET	OF


1.375
1.375
Ø4.25
A
A
B
B
1.375
1.386
1.386
0
1.375
1.
A
A
B
1.375
1.375



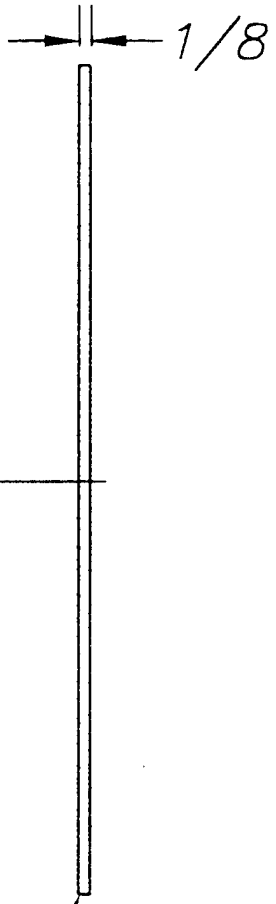
CHMF 0.01 x 0.01 @ 2

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XX ±.01 ±1° .XXX ±.005 DO NOT SCALE DRAWING	PROJECT NO. 810512.03
	DRAWN MF BOWEN
	CHECK
MATERIAL ALUMINUM 5052	
FINISH AS NOTED	AOP&E
	BIG 402

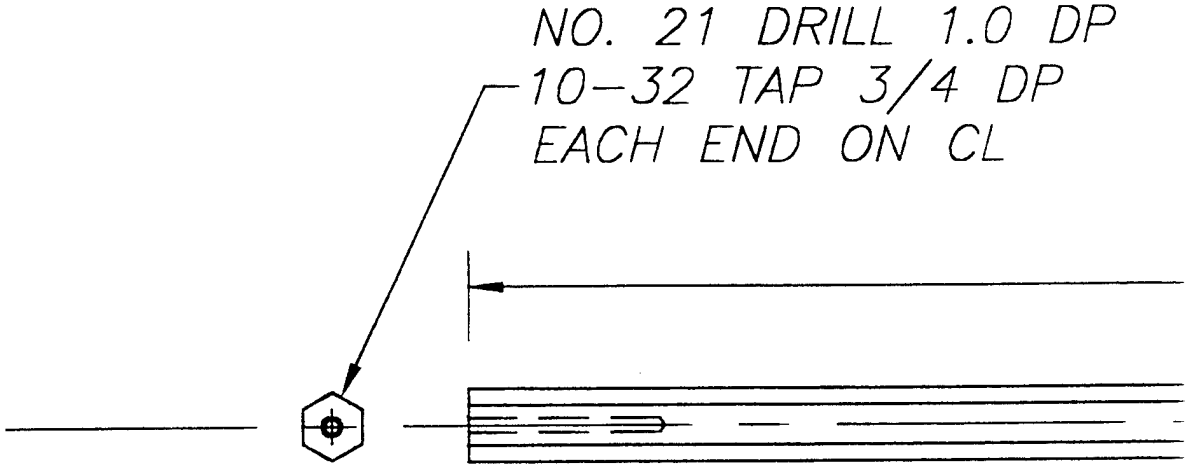
(2)

). 31 DRILL THROUGH 4 PL

'B) NO. 43 DRILL THROUGH
1–40 TAP 3 PL



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN / DATE 23 MAR 98	TITLE TRANSFER PLATE RING LASER GYRO
MATERIAL ALUMINUM 5052	CHECK / 11 x 17	
FINISH AS NOTED	AOP&E / MS #9	SIZE B / 23 / DWG NO. RLG–98–021
(3)	BIG 402 / 289–3420	SCALE NONE / RELEASE DATE / SHEET OF



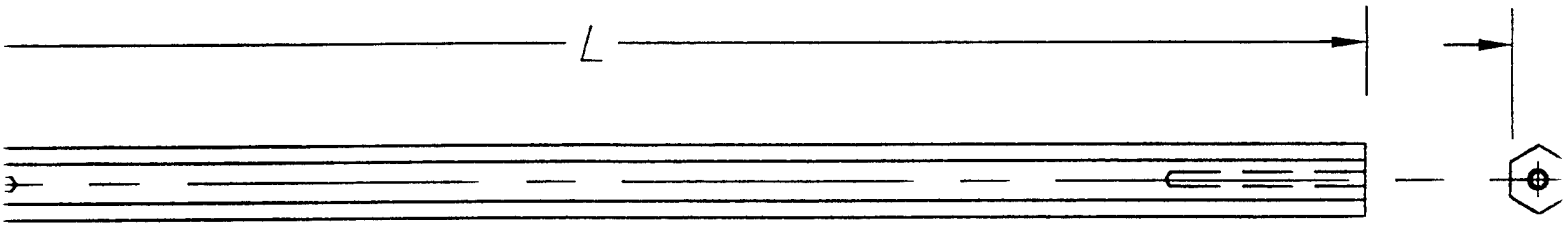
4 EA REQ'D WHERE L =

4 EA REQ'D WHERE L =

STOCK PROVIDED

(1)

21 DRILL 1.0 DP
32 TAP 3/4 DP
1 END ON CL



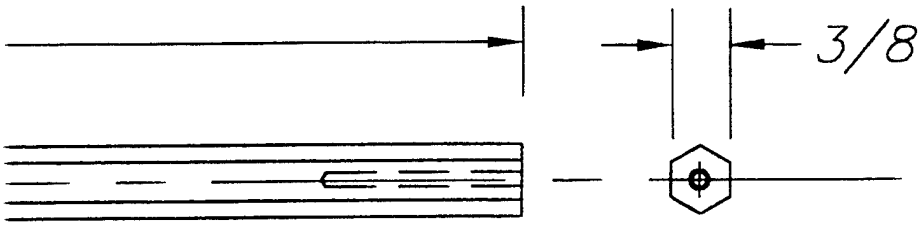
'Q'D WHERE L = 5.230

'Q'D WHERE L = 7.020

PROVIDED

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS ANGULAR .XX ±.01 ±1° .XXX ±.005 DO NOT SCALE DRAWING	PROJECT NO. 810512.03
	DRAWN MF BOWEN / DATE 23 MAR
	CHECK / 11 x 17
MATERIAL 6061-T6 AL HEX BAR	AOP&E / MS #3
FINISH AS NOTED	BIG 402 / 289-34

(2)



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS XX ±.01 XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 810512.03		WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543
	DRAWN MF BOWEN	DATE 23 MAR 98	TITLE SENSOR STACK SPACER RING LASER GYRO
	CHECK	11 x 17	
MATERIAL 6061-T6 AL HEX BAR			
FINISH AS NOTED	AOP&E	MS #9	SIZE B / 24 / DWG NO. RLG-98-022
	BIG 402	289-3420	SCALE NONE / RELEASE DATE / SHEET OF

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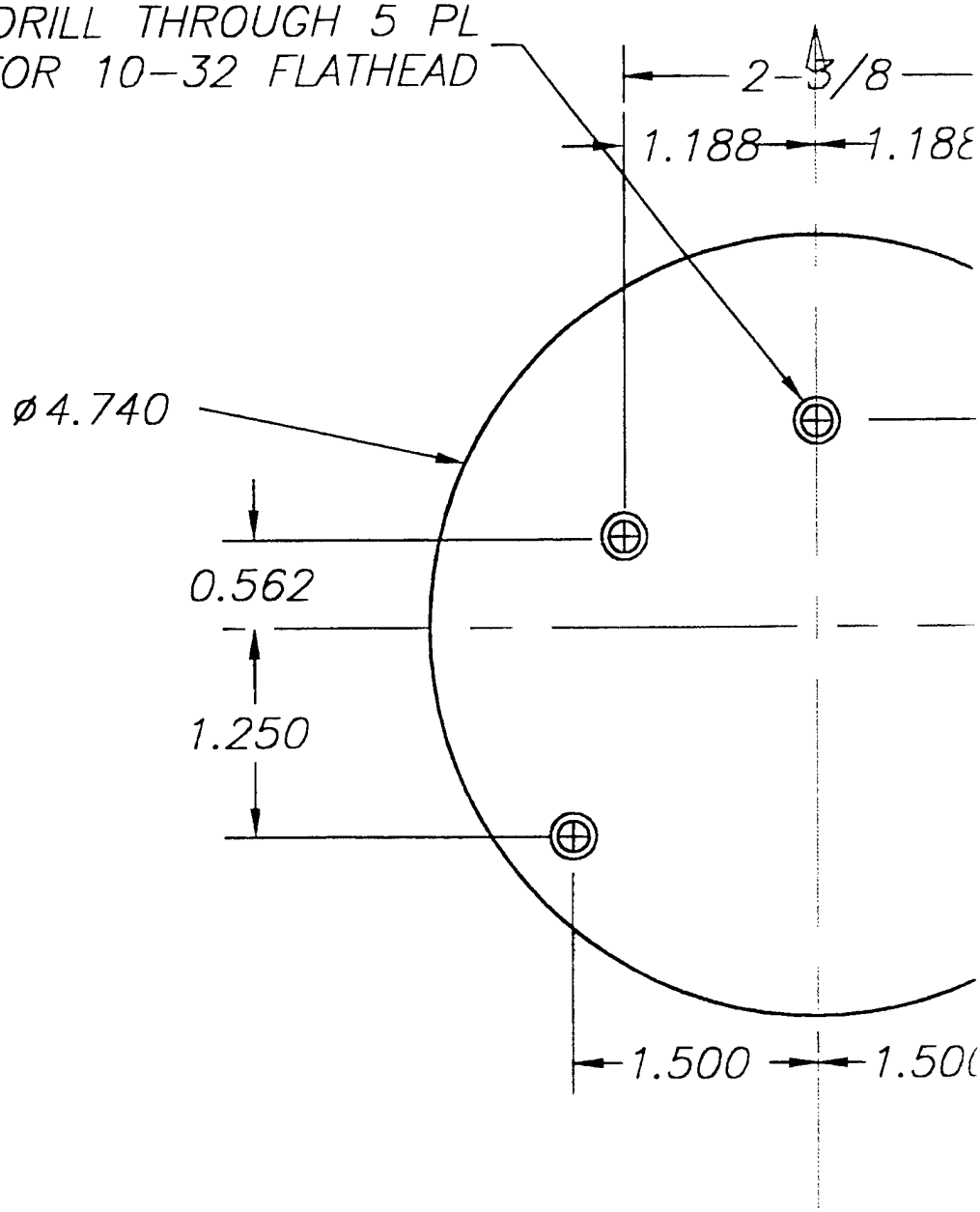
NO. 9 DRILL THROUGH 5 PL
CS THIS SIDE FOR 10-32 FLATHEAD



1 EA REQ'D
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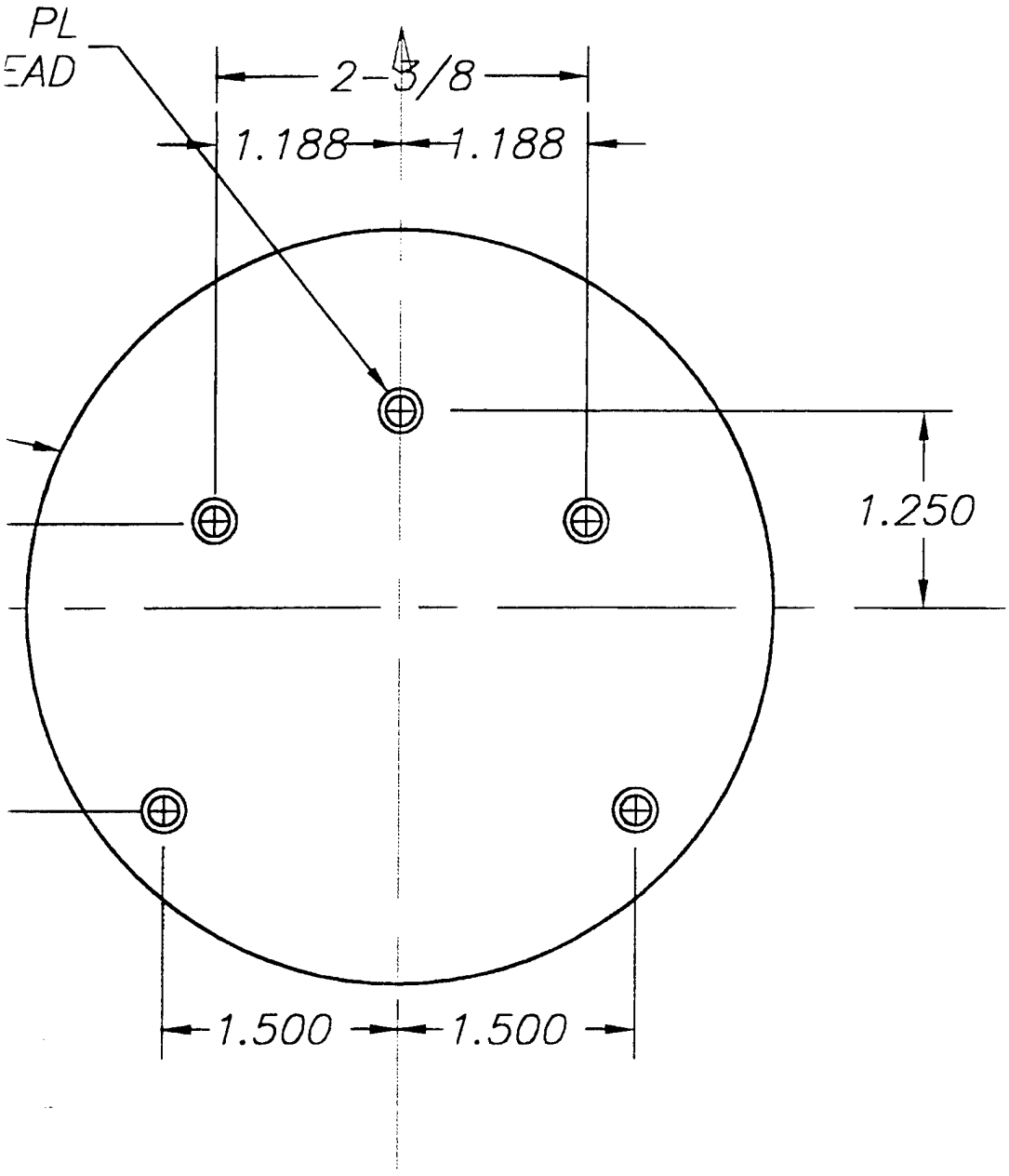
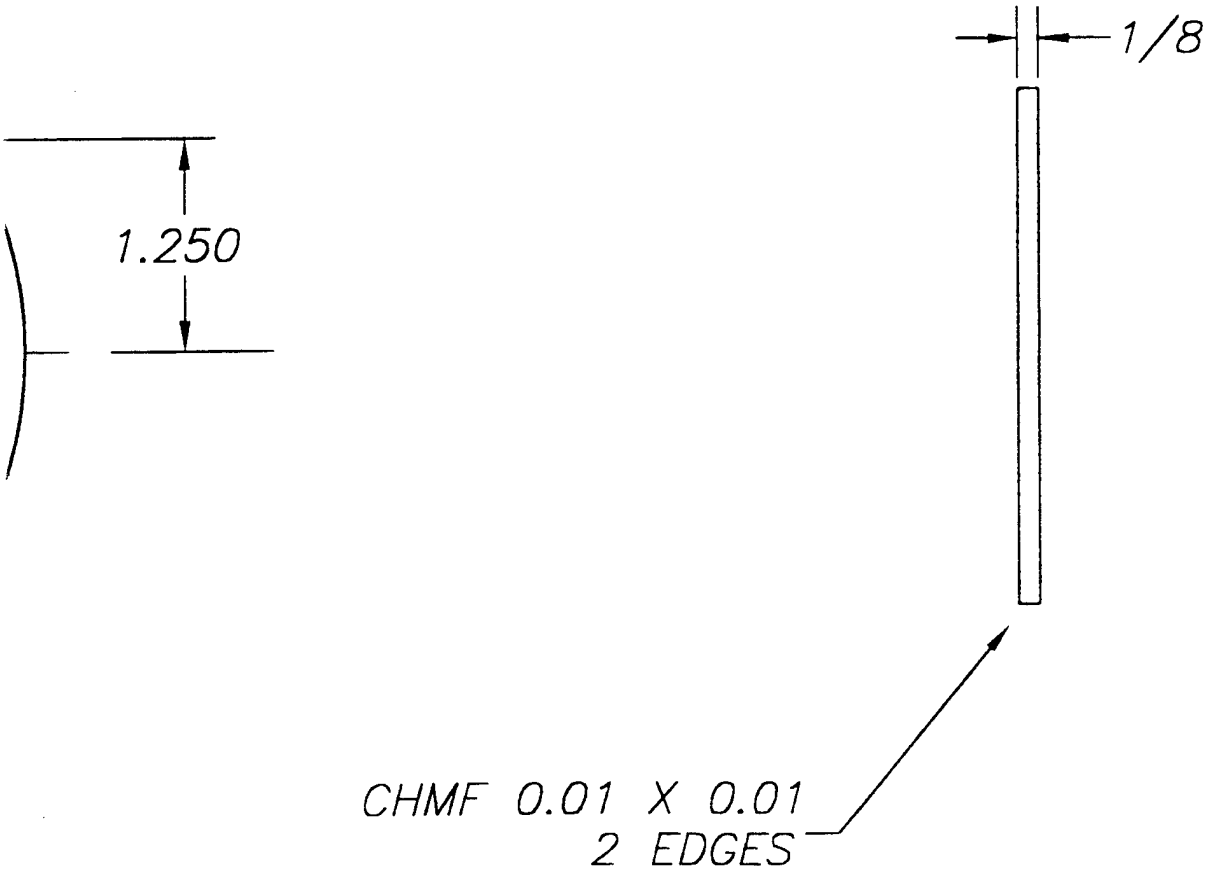


CHMF 0.01 X 0.0
2 EDGE.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 156168.08
	DRAWN MF BOWEN 9
	CHECK 11
MATERIAL ALUMINUM 5052 SHEET	
FINISH AS NOTED	AOP&E M
	BIG 402 28

(2)



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES DECIMALS .XX ±.01 .XXX ±.005 ANGULAR ±1° DO NOT SCALE DRAWING	PROJECT NO. 156168.08	WOODS HOLE OCEANOGRAPHIC INSTITUTION APPLIED OCEAN PHYSICS & ENGINEERING WOODS HOLE, MASSACHUSETTS, 02543	
	DRAWN MF BOWEN / DATE 9 Apr 98	TITLE BATTERY PACK PLATE RING LASER GYRO	
	CHECK / 11 x 17		
MATERIAL ALUMINUM 5052 SHEET	AOP&E / MS #9	SIZE B / 25	DWG NO. RLG-98-025
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16. Abstract (Limit: 200 words)

A Honeywell GG1320AN Digital Ring Laser Gyroscope (RLG), typically an aviation sensor, has been adapted for use as part of a navigation package rated to ocean depths of 6,000 meters. Researchers and engineers at the Deep Submergence Laboratory (DSL) of the Woods Hole Oceanographic Institution (WHOI) designed a high-density instrument package around the basic RLG. The integrated instrument is modular and field serviceable. It includes a chassis, housing, a Crossbow 6-axis dynamic measurement unit (DMU), battery backup, power regulation, support circuitry and robust interfaces. A pressure-proof titanium case and non-corroding accessories ensure that the RLG will remain unaffected by prolonged immersion in seawater. Associated mounting bracketry allow the housing to be axially registered alongside the navigation suites of various deep diving WHOI assets, or with any host platform capable of carrying a 25 pound payload. Primary RLG platforms will be the manned deep submergence vehicle ALVIN, the unmanned remotely operated vehicle JASON, and the unmanned autonomous vehicle ABE. As an extremely accurate yaw rate measuring device, the RLG will provide navigation data far more reliable and precise that has been available to scientists in the past. The WHOI RLG has been used successfully on one JASON cruise.

17. Document Analysis **a. Descriptors**
UUV
DSV
Gyro

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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